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Pig Development for the 90's

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PIG DEVELOPMENT

FOR THE 90'S

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National Pig Development (Canada) Co. Ltd.

and

Canada/Saskatchewan Economic Regional Development Agreement

prépared by

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ABSTRACT

Contractually, the primary objectives of this project were to research feet and leg structure in pigs and it's association with growth performance and also examine various aspects of prolificacy. Goals, relative to actual target values in April of 1987 (start of contract), were achieved. Details of related trials and data analyses are outlined in this technical report. Additional projects, related to product development and assessment were also included.

Over 11,000 performance tested pigs were scored for 17 separate front and back leg traits at the end of test. Preliminary analyses suggested that "straight legged" animals, those classified as slightly up on their toes with very little "bend" in their pasterns were more likely to be culled for feet and leg problems at an earlier age. These traits were moderately heritable and selection efforts to achieve a more desirable leg structure would be rewarded. There was no evidence to support the notion that faster growing pigs had poorer feet and leg structure.

First litter traits were not significantly associated with test performance, but there was a tendency for faster growing gilts to farrow larger litters. Examination of pre-farrowing backat levels and litter traits underlined the need to maintain adequate condition of sows at all times. Other studies revealed a positive association between age at first service and litter size, and between number of matings and conception rate and litter size.

The benefits of introducing external stock, via A.I. were clearly demonstrated in a number of sections throughout the report. Most notable was the level of heterosis in first and second parity A.I. daughters. Sampling of external stock, and incorporation of those animals which merit inclusion, was and is a viable option in the pursuit of continued improvements.

Over the last decade, there has been an increased awareness of the problems associated with Porcine Stress Syndrome and PSE meat. As part of the project, halothane testing was initiated in March of 1988 and continues to be applied. A study on carcass composition and meat quality of Nucleus pigs revealed that, compared to current commercial pig averages, NPD pigs offered a 5 to 6 point advantage in carcass value with a corresponding advantage of 3 to 4% in carcass lean yield. Despite the leanness of carcasses, meat quality was more than acceptable in both breeds.

Competition, in both domestic and foreign markets, is becoming increasingly fierce and pig producers must have access to continually improved breeding stock if they are to compete successfully. Accordingly, all activities carried out over the term of this project were conducted with a view to offering pig producers an improved product.

ACKNOWLEDGEMENTS

National Pig Development (Canada) Co. Ltd. (N.P.D.) acknowledges with thanks the financial support of the Canada/Saskatchewan Economic Regional Development Agreement (ERDA) for this project. The project was administered by Dr. John Taylor, whose assistance and support were greatly appreciated.

The advisory committee, which included Dr. Alan Theede (Chairman), Dr. Harold Fast and Mr. Don Kolla, met regularly with N.P.D. representatives over the term of the project. The committee's involvement, support and guidance were invaluable and very much appreciated.

Within N.P.D., a number of people deserve special mention. Their efforts and dedication to the project were instrumental in ensuring it's successful completion. They were Mr. Ed Johnson (president and general manager), Mr. Bruce Owen (production manager), Mr. Don Larson and Mr. Courtney Ward (production staff) and Mr. Florian Possberg (Nucleus owner and operator).

I would also like to mention several other people whose help and advice the last three years was certainly appreciated: Dr. Jon Mercer (geneticist, N.P.D. (England)), Dr. Brian Kennedy (professor, University of Guelph) and Dr. Roger Cue (assistant professor, Macdonald College, McGill University).

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I.1

CONTRACT

OBJECTIVE

Research and develop a structurally improved breeding animal designed for longevity under variable management conditions.

BACKGROUND AND RATIONALE

Structural Soundness

Culling of sows for locomotion problems in Britain, Australia and Denmark over the last 10 years shows rates varying from 10% to 33% of animals culled. In a survey of herds in his own practice in the U.K., Dr. Mike Muirhead demonstrated a cull rate of over 10% for leg problems of which 60% occurred during the first three parities. These animals were prevented from reaching the highly productive 4th through 7th parities.

ACTION PLAN

a) Current Base Line	* 30% culled for leg problems at an average parity of 1.63	
Goals	* March 31, 1988	0.0% improvement
	* March 31, 1989	-2.5%
	* February 1, 1990	-2.5%

An objective of the program is to establish a subjective method of measuring structural soundness in relation to growth and performance capabilities.

b) Point of program is and will be to develop criteria to establish an objective method of defining structural soundness. At present time each individual person's opinion is as they see the animal, can we put this into a measurable method of analysis ? Planned program would include:

- Appraisal score for various leg traits. Separate leg traits will be assigned for both front and rear legs plus an aggregate leg score will be derived from the separate trait scores. Categories will be established for scoring using numbered values respectively. Please refer to Table I.1 (1) and I.1 (2) of "Genetics of Leg Weakness in Boars" as a basis of program development.

c) Average age of culling for locomotion problems is 1.63 parities. Goals for improvement are:

* March 31, 1988	0.00 improvement
* March 31, 1989	1.75 parities
* February 1, 1990	1.90 parities

Table I.1 (1)
Structure of the data[1]

Observation	Start of test (27kg)		End of test (91 kg)	
	Large White	Landrace	Large White	Landrace
No. of testing stations represented	4	4	4	4
No. of herds represented	232	157	232	157
No. boars scored for leg condition	11422	7266	14365	9610
Degrees of freedom for sires[a]	1654	1226	2123	1601
Coefficients of mean squares[b]				
k_1	1.97	1.98	2.07	2.08
k_2	2.35	2.29	2.10	2.07
k_3	6.39	5.50	6.76	6.00

[1] Webb, A.J., Russell, W.S. and Sales, D.I. 1983. Genetics of leg weakness in performance-tested boars. Anim. Prod. 36:117-130. (Table 1).

[a] For genetic correlations between boar leg and performance traits.

[b] Expected value of dam mean square = $\sigma_w^2 + k_1\sigma_d^2$ and of sire mean square = $\sigma_w^2 + k_2\sigma_d^2 + k_3\sigma_s^2$, where σ_s^2, σ_d^2 and σ_w^2 are sire, dam and within-litter components of variance respectively.

Table 1.1 (2)

Proportional incidence of individual leg traits scored as either 'slight' or 'severe' at the start (27 kg) and end (91 kg) of test[1]

	Large White				Landrace			
	Start		End		Start		End	
Leg Attributes	Slight	Severe	Slight	Severe	Slight	Severe	Slight	Severe
General Action								
Hindquarters twisting	0.16[a]	0.01	0.28	0.06	0.31	0.07	0.47	0.25
Hind legs crossing	0.03	0.01	0.07	0.03	0.03	0.01	0.06	0.03
Hind legs								
Hocks closeness	0.70	0.08	0.60	0.13	0.41	0.02	0.25	0.02
Sickle-hocked	0.17	0	0.28	0.02	0.49	0.02	0.59	0.11
Bow-legged	0.01	0	0.02	0	0.04	0	0.08	0.01
Legs turned in	0.04	0	0.09	0.02	0.15	0.02	0.26	0.12
Legs turned out	0.71	0.06	0.60	0.11	0.59	0.05	0.38	0.07
Up on toes	0.11	0	0.11	0.01	0.06	0	0.06	0
Down at pasterns	0.03	0	0.04	0	0.06	0	0.08	0.01
Clays uneven	0.56	0.01	0.59	0.05	0.64	0.02	0.64	0.06
Fore legs								
Knock-kneed	0.17	0.01	0.18	0.02	0.09	0	0.14	0.02
Bow-legged	0.01	0	0.01	0	0.03	0	0.06	0.01
Over at knee	0.11	0	0.11	0.01	0.14	0	0.14	0.01
Legs crossing	0	0	0.01	0	0.01	0	0.04	0.01
Legs turned in	0.06	0	0.06	0	0.16	0	0.24	0.03
Legs turned out	0.51	0.07	0.45	0.10	0.44	0.03	0.36	0.07
Up on toes	0.02	0	0.04	0.01	0.02	0	0.04	0.01
Down at pasterns	0.22	0.01	0.20	0.03	0.24	0	0.17	0.03
Clays uneven	0.30	0	0.39	0.02	0.32	0	0.47	0.02

[1] Webb, A.J., Russell, W.S. and Sales, D.I. 1983. Genetics of leg weakness in performance-tested boars. Anim. Prod. 36:117-130. (Table 2).

[a] s.e. of differences between breeds, and between start and end within breeds, range from 0.001 to 0.007

I.2

REALIZATION OF ACTION PLAN

a) Contract and actual culling rates or feet and leg problems in the sow herd

	Contract	Actual	Contract - Actual
Apr 87 - Mar 88	30.00%	35.60%	-5.60%
Apr 88 - Mar 89	27.50%	29.05%	-1.55%
Apr 89 - Feb 90	25.00%	31.31%	-6.31%
Improvement	5.00%	4.29%	

The original contract value specifying an annual cull rate of 30% for feet and leg problems was based on herd information ending August of 1986. Between August 1986 and initiation of the project in April of 1987, a number of changes had taken place in the Nucleus, namely, an expansion of the herd from 250 to 500 sows. With the expected settling down process of a gilt expansion process, the actual percentage of culls due to feet and legs was 35.6% at the start of the project, not 30% as originally specified. Although subsequent target values were never achieved, an improvement of 4.29% was seen over the term of the project.

Since the Nucleus must maintain a minimum annual replacement rate in females of 80%, a reduction in the percentage of culls due to feet and legs could only be brought about by a corresponding increase in other reasons for cull. It is more appropriate to gauge improvement as the proportion of sows culled for feet and leg problems relative to the total number of sows in the herd, rather than the total number of sows culled. Figure I.2 (1) depicts the number of sows culled for structural soundness as a percentage of total sows in the herd. Over the term of the project, a definite improvement was noted. The regression of month-year of cull on percentage culls indicated a two-fold improvement from 2.06% to 1.16%. Monthly reductions were in the order of 0.03%.

b) Initiation of structural soundness scoring system

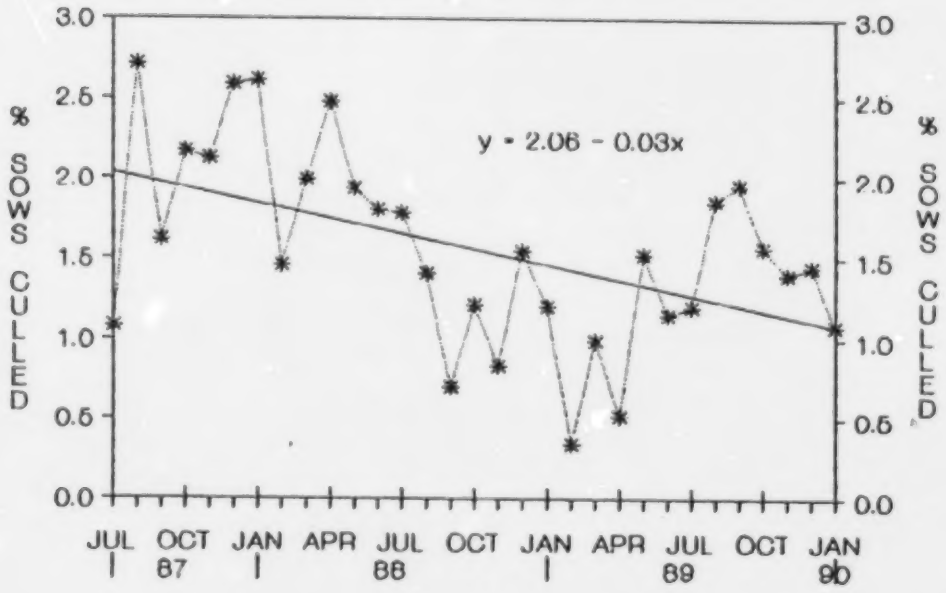
In March of 1988, a comprehensive feet and leg scoring system was introduced in the Nucleus unit. Details and results of the program are reviewed in sections I.3.1 through I.3.6.

c) Contract and actual culling ages (parity) for locomotory problems

	Contract	Actual	Contract - Actual
Apr 87 - Mar 88	1.63	1.43	-0.20
Apr 88 - Mar 89	1.75	1.56	-0.19
Apr 89 - Feb 90	1.90	1.35	-0.55
Improvement	0.27	-0.08	

Reasons for the discrepancy between original contract and actual values were listed in part a) of this section (I.2). An improvement was noted in year 2 of the contract, however this was not sustained. In April of 1989, which began the 3rd year of the contract, the organism responsible for mycoplasma hyopneumonia was detected. A program to temporarily increase the existing Nucleus from 500 sows to 800 sows was initiated in order that a second Nucleus could be stocked with mycoplasma-free pigs. Limitations on space required the additional sows be group housed in feeder pens throughout their gestation. The percentage of gilts culled for feet and leg problems prior to farrowing their first litter increased from 28% in previous years to 43%. Understandably, this had a definite effect on the average parity of sows culled for feet and legs in the herd.

Figure I.2 (1)
Sows Culled for Feet and Leg Problems as
a Percentage of Total Sows in the Herd



I.3
RESEARCH PROJECTS

I.3.1 GENERAL INTRODUCTION

To re-iterate, the first objective was to "research and develop a structurally improved breeding animal designed for longevity under variable management conditions". As a first step, a system for scoring feet and leg structure was needed. An adaptation of the system proposed by Webb et al. (1983) was implemented. A total of 17 front and back leg traits were scored on each pig completing performance test. The traits measured included:

	(1) gait		
Front	(2) knock knees	Back	(10) closeness of hocks
	(3) over at knee		(11) sickle hocks
	(4) bow leggedness		(12) bow leggedness
	(5) turning in		(13) turning in
	(6) turning out		(14) turning out
	(7) down at pasterns		(15) down at pasterns
	(8) up on toes		(16) up on toes
	(9) uneveness of toes		(17) uneveness of toes

Traits were scored as either 0 (normal), 1 (moderate abnormality) or 2 (severe abnormality). Since the ability to select for improvement in a trait is contingent upon the existence of genetic variation or differences in that trait, evidence of variation was needed. In the case of categorical traits (0, 1 or 2), frequency distributions of scores for each trait were used to determine whether or not variation was evident (I.3.2). Once determined, the heritability or proportion of variation due to the additive effects of genes was estimated. Should any feet and leg trait(s) be found to predispose animals to feet and leg problems, heritabilities would be needed to determine whether selection to alter leg structure was feasible.

The repeatability of scores between and within evaluator were also computed (I.3.4). Between evaluator repeatabilities were considered an indication of agreement between scorers, while within evaluator repeatability was considered a measure of reproducibility (i.e. chance the same evaluator assigned the same score to the same pig on two separate occasions).

For the most part, the utility of a feet and leg scoring system lies in it's ability to predict survival and identify individuals most likely to fail because of feet and leg problems. This was accomplished by deriving survival functions of

females scored for feet and legs and dispatched to Nucleus and Multiplication herds (I.3.5).

Trends in feet and leg culls throughout the Multiplication system, which represent a variety of management conditions, were calculated and are presented in section I.3.6.

I.3.2
FREQUENCY DISTRIBUTION OF FEET AND LEG SCORES

INTRODUCTION

The objective of this exercise was to calculate the distribution of normal (0), moderately abnormal (1) and severely abnormal (2) scores for each of the 17 front and back leg traits and, using this information, determine which trait(s) exhibited a reasonable amount of variation.

EXPERIMENTAL DESIGN

Between March of 1988 and November of 1989, a total of 11,017 pigs were scored for feet and leg structure at the end of performance test. The group was comprised of 3002 Landrace and 2910 Large White females, and 2266 Landrace and 2839 Large White boars.

RESULTS

Frequency distributions for feet and leg traits are presented for each breed and sex in Figures I.3.2 (1a, b, c and d). The virtual absence of abnormal scores for 'legs turning in' and ''bow leggedness' in both the front and back legs, as well as 'legs crossing over' in the front suggest there was little value in scoring these traits. Accordingly, the traits were omitted from subsequent analyses. Webb et al. (1983) also found very little variation in the traits 'bow leggedness' and 'legs crossing over'. However, unlike this study, 'legs turning in' was retained while 'up on toes' in both the front and back legs and 'down at pasterns' in the back legs were excluded.

Many scoring systems are limited to two categories; namely, the absence or presence of an abnormality. The addition of a third category to distinguish between moderate and severe abnormalities may or may not be warranted. In this study, where two breeds and two sexes were scored using the same system, it's inclusion appears to have been warranted in most cases. For instance, although no females were found to have severe 'knock knees' in the front legs, a small proportion of males did. Similarly, 'closeness of hocks' in the back legs of Large Whites was never reported as severe, yet a small percentage of Landrace pigs were found to have extremely close back hocks.

SUMMARY

The frequency distribution of scores for each of the 17 front and back leg traits revealed little use for the traits 'legs turning in' and 'bow leggedness'

in the front and back legs, as well as 'legs crossing over' in the front. The contrast in distributions between this population and that studied by Webb et al. (1983) suggest there are differences in leg structure between different populations. And, given this, breeders considering selection for feet and leg structure would be well advised to determine the frequency of scores in their particular population of pigs.

REFERENCES

Webb, A.J., Russell, W.S. and Sales, D.I. 1983. Genetics of leg weakness in performance-tested boars. Anim. Prod. 36:117-130.

Figure I.3.2 (1a)
Distribution of Feet and Leg Scores
* Landrace Females *

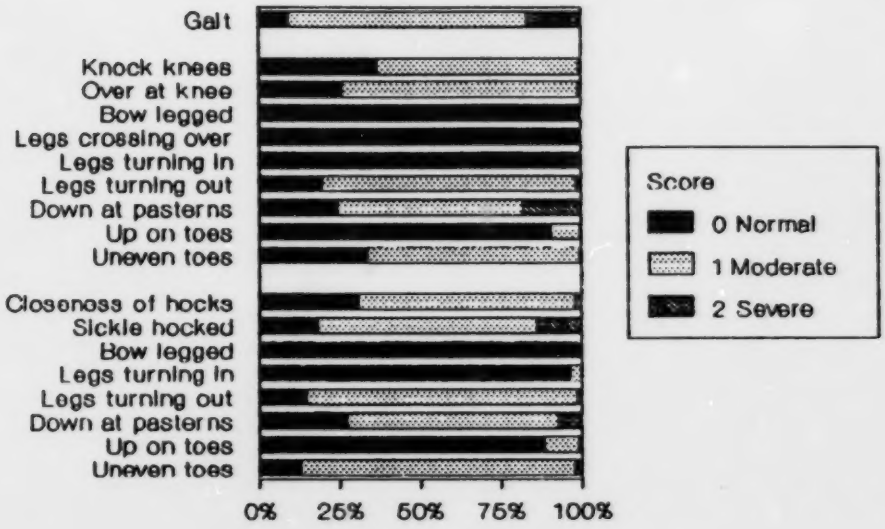


Figure I.3.2 (1b)
Distribution of Feet and Leg Scores
* Landrace Males *

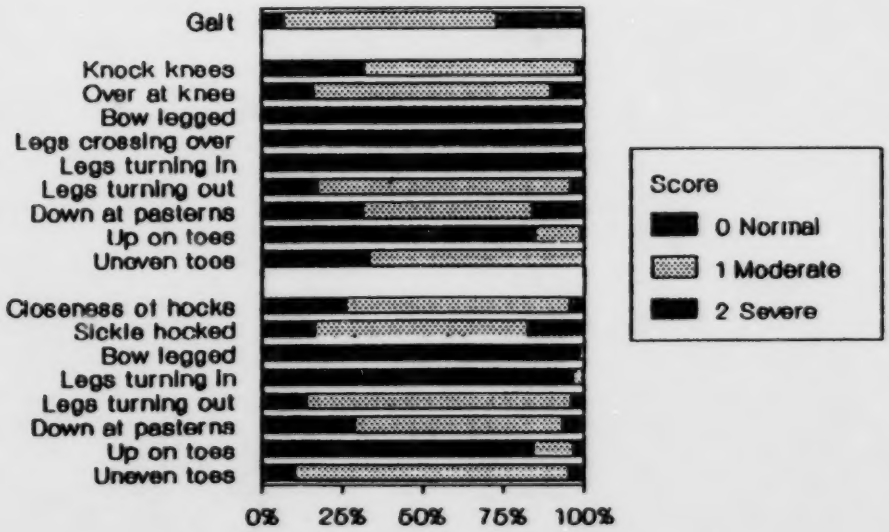


Figure I.3.2 (1c)
Distribution of Feet and Leg Scores
* Large White Females *

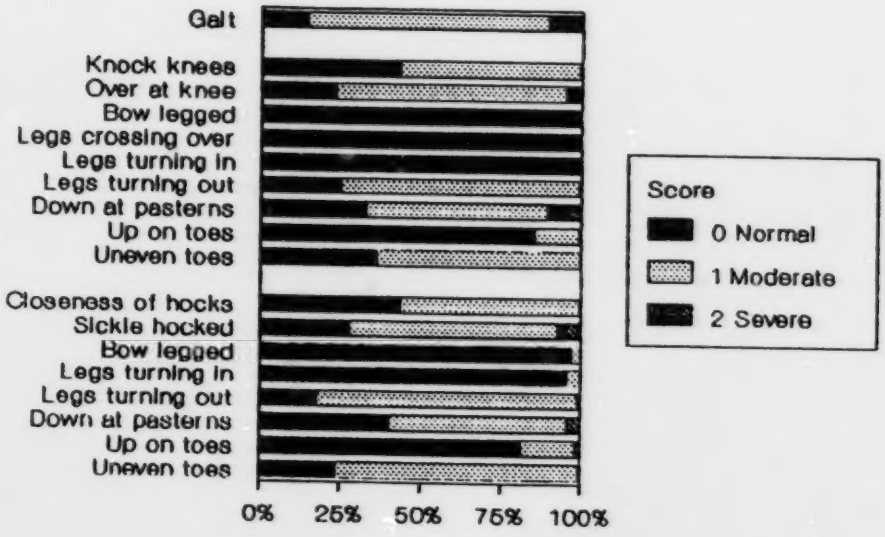
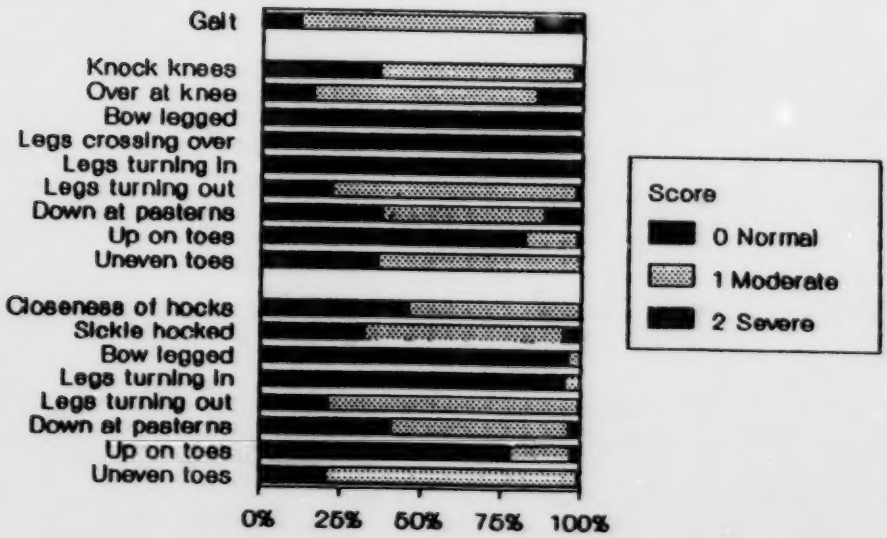


Figure I.3.2 (1d)
Distribution of Feet and Leg Scores
* Large White Males *



I.3.3

GENETIC AND PHENOTYPIC PARAMETERS OF FEET AND LEG TRAITS

INTRODUCTION

The objective of this study was to estimate the heritability of feet and leg traits.

EXPERIMENTAL DESIGN

Records were available on 5268 Landrace and 5749 Large White pigs scored for feet and leg traits between March 1988 and November 1989. Pigs were scored by either one of two evaluators and included both group tested males and females as well as individually feed tested males. Group test pigs (-FC) were housed in groups of 12 while individually feed tested boars (+FC) were housed in groups of 5. Pigs were placed on test at approximately 40 kg for a period of 8 weeks. At the end of test, pigs were weighed and scored for feet and leg structure. Traits included gait, and in the front legs : knock knees, over at knee, legs turning out, down at pasterns, up on toes and uneveness of toes, and in the back legs : closeness of hocks, sickle hocks, legs turning out, down at pasterns, up on toes and unevenss of toes. An aggregate leg score, which was the sum of individual feet and leg scores, was also computed. Distribution of records across evaluator, sex and type of test are reported in Table I.3.3 (1). Breeds were analysed separately and only records of sires with a minimum of 10 progeny were retained for analysis. A total of 44 Landrace and 48 Large White sires were represented. As well, there were 438 Landrace dams and 503 Large White dams represented in the population.

A restricted maximum-likelihood (REML) program was used to estimate variance components (Meyer, 1987). REML is an iterative procedure and the system was assumed to have converged when the difference in estimates of variance components from one round of iteration to the next was less than 10^{-8}%. The following model was used for the analysis:

$$y_{ijklmno} = u + b_1 X_{1ijklmno} + ys_i + sex_j + test_k + evaluator_l + sire_m + dam_n + error_{ijklmno}$$

$y_{ijklmno}$ is a feet and leg score on the ijklmnoth pig,
u is the population mean,
$b_1 X_{1ijklmno}$ is the regression of feet and leg score on weight (kg) at scoring,
ys_i is the fixed effect of the i^{th} year-season of test, i= 1, 6,

sex_j	is the fixed effect of the j^{th} sex of pig, j = F, M,
$test_k$	is the fixed effect of the k^{th} type of test, k = group test (-FC), individual feed test (+FC),
$evaluator_l$	is the fixed effect of the l^{th} evaluator, l = 1, 2,
$sire_m$	is the random effect of the m^{th} sire, N (0, V_s),
dam_n	is the random effect of the n^{th} dam, N (0, V_d),
$error_{ijklmno}$	is the random error associated with an observation on the $ijklmno^{th}$ pig, N (0, V_e).

Year-seasons, based on the start of test day, were classified into one of three 4 month periods (1: jan-apr, 2: may-aug, 3: sep-dec) within a year (1988, 1989). Since many of the dams farrowed several litters sired by different boars, dams were considered cross-classified with sires.

Heritability (h^2) of traits was estimated as (4.0 * V_s) / (V_s + V_d + V_e).

RESULTS

Fixed Effects

Differences in feet and leg score between sexes (F vs M), type of test (Group test vs Individual feed test) and evaluators (2 vs 1) are given in Table I.3.3 (2) for both breeds. Differences superscripted with an asterisk were significantly different ($P < .05$).

With the exception of 'down at pasterns' in the front legs, Landrace females were consistently assigned lower, or more "normal" scores when compared to males. differences were significant for all traits except 'legs turning out' in both the front and back legs. This same consistency was not evident when comparing Large White females and males. Although Large White females tended to have better, or lower, front leg scores, males had scores nearer 0 for 'closeness of hocks', 'down at pasterns', 'sickle hocks' and 'legs turning out' in the back legs. Of these, differences in the last two were significant.

Group test pigs, housed in groups of 12 pigs/pen, had worse gait scores and were more likely to be 'up on their toes' in the back legs than individually feed tested pigs housed in pen groups of 5. Conversely, group housed pigs had significantly higher 'legs turning out' and 'up on toes' scores in the front legs, while group housed Large White's showed higher 'legs turning out' scores in the back legs.

Significant differences between evaluators were noted for all traits. Compared to evaluator 1, 'aggregate leg score' was significantly lower in both breeds when scored by evaluator 2.

Heritabilities

Heritability estimates for each breed and trait are presented in Table I.3.3 (3). Heritabilities were generally lower in Landrace than in Large Whites. The highest heritabilities were for 'gait', 'down at pasterns', and 'up on toes' in the front legs, and 'sickle hocks', 'down at pasterns' and 'up on toes' in the back legs. Except for 'down at pasterns' in the front legs which was excluded from Webb et al. (1983)'s study, estimates were similar. The heritability of aggregate leg score was .10 for Landrace and .17 for Large Whites.

SUMMARY

Undoubtedly, there exists a genetic component to feet and leg structure. And, although progress would be slow, selection for certain aspects of leg structure would be possible. This same conclusion has been reached by a number of researchers (Bereskin, 1979; Webb et al., 1983) and indeed, Draper et al. (1988) noted significant differences in the resting angles of several major joints following 5 generations of divergent selection for leg weakness in Duroc swine.

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Table 1.3.3 (1)

Distribution of records across sexes, type of test and evaluators

		Landrace	Large White
Total number of records		5268	5749
Sex	M	2266	2839
	F	3002	2910
Test	-FC	1149	1736
	+FC	4119	4013
Evaluator	1	3585	3788
	2	1683	1961

Table 1.3.3 (2)

Differences between sexes, type of test and evaluator on feet and leg traits

	Sex Females - Males		Type of test (-FC) - (+FC)		Evaluator 2 - 1	
	Landrace	Large White	Landrace	Large White	Landrace	Large White
Gait	-.1560*	-.0967*	.0566*	.0423*	-.3044*	-.2942*
Front legs:						
knock knees	-.0664*	-.0818*	-.0245	-.0434	-.4306*	-.3769*
over at knee	-.0845*	-.1516*	-.0365	-.0383	.0597*	-.0152
turning out	-.0151	-.0684*	-.0428*	-.0352*	-.2678*	-.3167*
down at pasterns	.0699*	.0295	.0421	.0265	.0623*	.1507*
up on toes	-.0532*	-.0198	-.0454*	-.0361*	.0306*	-.0634*
uneveness of toes	na	-.0235	na	.0420*	na	-.3501*
Back legs:						
closeness of hocks	-.0722*	.0252	-.0012	-.0176	.2469*	.2461*
sickle hocks	-.0740*	.0667*	.0348	.0150	-.1444*	-.3687*
turning out	-.0223	.0655*	-.0207	-.0348*	.0558*	-.0553*
down at pasterns	.0437*	.0323	-.0372*	-.0211	.3519*	.2510*
up on toes	-.0751*	-.0405*	.0409*	.0114*	-.1257*	-.0503*
uneveness of toes	-.0318*	-.0312*	-.0200	-.0267	-.1730*	-.3921*
Aggregate leg score	-.5569*	-.3084*	-.0328	.0160	-.9543*	-1.5120*

Table 1.3.3 (3)

Heritability of feet and leg traits

	Landrace	Large White
Gait	.0636	.1314
Front legs:		
knock knees	.0221	.0612
over at knee	.0320	.0887
turning out	.0420	.0408
down at pasterns	.2157	.3168
up on toes	.0713	.1690
unevenness of toes	na	.0228
Back legs:		
closeness of hocks	.0182	.0339
sickle hocks	.0632	.1210
turning out	.0139	.0488
down at pasterns	.0773	.1354
up on toes	.0674	.1094
unevenness of toes	.0446	.0313
Aggregate leg score	.1018	.1646

I.3.4

REPEATABILITY OF FEET AND LEG TRAITS BETWEEN AND WITHIN EVALUATOR

INTRODUCTION

The correlation between two or more measurements on the same trait is termed 'repeatability' and has several applications. Namely, to show how much is to be gained by the repetition of measurements, to set upper limits on estimates of heritability and to predict future performance from past records (Falconer, 1989).

In March of 1988, a comprehensive system for scoring feet and leg structure of pigs was introduced in an NPD Nucleus unit at Humboldt, Saskatchewan. At that same time, a two-day trial was carried out to estimate the repeatability of these scores, both between evaluators and within evaluator and pig.

EXPERIMENTAL DESIGN

Three evaluators independently scored 140 performance tested pigs. The group comprised 22 Large White (LW) boars, 27 Landrace (LR) boars, 52 LW females and 39 LR females.

Pigs were evaluated for gait and 17 separate front and back leg traits. The traits and scoring method were an adaptation of the system outlined by Webb et al. (1983). Scores for each trait were assigned as 0 (normal), 1 (slight abnormality) or 2 (severe abnormality). The same pigs were re-scored the following day.

Data were analysed using SAS's (1985) VARCOMP procedure (REML option) according to the following model:

$$y_{ijklm} = u + breed_i + sex_j + evaluator_k + pig_{il} + error_{ijklm}$$

y_{ijklm}	feet and leg score on the $ijklm^{th}$ pig,
u	population mean,
$breed_i$	fixed effect of i^{th} breed, i = LR, LW,
sex_j	fixed effect of the j^{th} sex, j = F, M,
$evaluator_k$	random effect of the k^{th} evaluator, N $(0, V_v)$,
pig_{il}	random effect of the l^{th} pig within the i^{th} breed, N $(0, V_p)$,
$error_{ijklm}$	random error associated with $ijklm^{th}$ pig, N $(0, V_e)$.

Repeatability of scores between individual evaluators, interpreted as an indicator of agreement among evaluators (i.e. the likelihood different evaluators assigned the same score to the same pig), was calculated as $R_b = V_v / (V_v +$

$V_p + V_e$). Repeatability of scores within evaluator and pig, interpreted as an indicator of agreement within evaluators (i.e. the likelihood an evaluator assigned the same score to the same pig on two separate occasions), was calculated as $R_w = V_p / (V_v + V_p + V_e)$.

RESULTS

Distribution of scores

Figures I.3.4 (1.a and b),(2.a and b) and (3.a and b) illustrate the frequency distribution of feet and leg scores for each evaluator on both days.

With the exception of evaluator 1, the categories for 'bow leggedness', 'legs turning in' and 'legs crossing' in the front legs, as well as legs 'turning in' and 'bow leggedness' in the back legs were of little use; 90% or more of the pigs were assigned normal scores of 0. In contrast, variation was evident in the remaining 13 traits.

REPEATABILITY

Repeatabilities are provided in Table I.3.4 (1).

i) Between Evaluator

The repeatability of 'gait' was 20%. Values for front leg traits ranged from 2% for 'legs crossing over' through 38% for 'down at pasterns'. Agreement between evaluators was greatest for traits 'legs turning out' (.18), 'down at pasterns' (.38) and 'up on toes (.29)'.

The moderate repeatability of .21 for 'legs turning in' likely reflects the designation of normal scores (0) to all pigs by two of the three evaluators.

Repeatabilities for back leg traits were somewhat lower. Estimates for 'down at pasterns' and 'sickle hocks' were .20 and .13, respectively. Repeatabilities of remaining traits were less than 10%.

ii) Within Evaluator and Pig

Comparison of between and within evaluator repeatabilities for front leg traits suggests evaluators were more likely to agree among themselves than assign the same score to the same pig on two separate occasions. The reverse trend was observed for most back leg traits.

Repeatabilities were highest for 'gait' (.20), 'down at pasterns' in both the front (.19) and back (.17) legs and 'up on toes' (.20) in the back legs.

iii) Gains in Accuracy

Variation in phenotypes (V_P) is the sum of genetic (V_G), permanent (V_{Ep}) and temporary (V_{Et}) environmental effects. In this study, an example of a permanent environmental effect may have been the barn in which the pigs were raised, whereas an example of a temporary environmental effect may have been slipperiness of the floor from one day of scoring to the next.

The increase in accuracy due to repeated measurements is brought about by a reduction in temporary environmental variance (V_{Et}) which, in turn results in higher heritability estimates ($h^2 = V_G / V_G + V_{Ep} + V_{Et}$). It is related to the number of measurements taken and the increase in accuracy due to repeated measures can be computed as follows:

$$V_{P(n)} / V_P = (1 + r(n - 1)) / n$$

$V_{P(n)}$ is the phenotypic variance of an average of 'n' measurements on pig 'P',
V_P is the phenotypic variance of a single measurement on pig 'P',
r is the repeatability of the trait,
n is the number of measurements.

In Figure I.3.4 (4), the variance of the mean of 'n' measurements ($V_{P(n)}$) as a percentage of the variance of a single measurement (V_P) was plotted against the number of measurements. Reductions in phenotypic variance due to repeated measures were greatest in traits with low repeatabilities.

Repeatability estimates of most feet and leg traits were found to be 20% or less. Therefore, two measurements scored on the same pig by the same evaluator would be expected to yield a 40% reduction in phenotypic variance. And similarly, three evaluators scoring the same pig would be expected to result in a gain in accuracy of 53%.

SUMMARY

There was little, if any, variation in the following traits: 'legs turning in' and 'bow leggedness' in both front and back legs and front 'legs crossing'. Exclusion of these traits from future evaluations seems warranted.

Repeatability within evaluator and pig can also be interpreted as an upper limit on heritability. For instance, given a repeatability of 20%, we would not expect the estimate of heritability for that trait to exceed 20%. The most repeatable and likely most heritable traits were 'gait' (20%), 'over at knee' (19%) and 'down at pasterns' (19%) in the front legs, as well as 'down at pasterns' (.17), 'up on toes' (.20) and 'uneveness of toes' (.15) in the back legs.

The generally low estimates of repeatability suggest repetition of measurements would be advantageous.

REFERENCES

Falconer, D.S. 1989. Introduction to quantitative genetics. pp 139-144.

Statistical Analysis System. 1985. SAS/STAT Guide. SAS inst. Inc., Cary, N.C.

Webb, A.J., Russell, W.S. and Sales, D.I. 1983. Genetics of leg weakness in performance-tested boars. Anim. Prod. 36:117-130.

Figure I.3.4 (1a)
Distribution of Day 1 Scores
• Evaluator 1 •

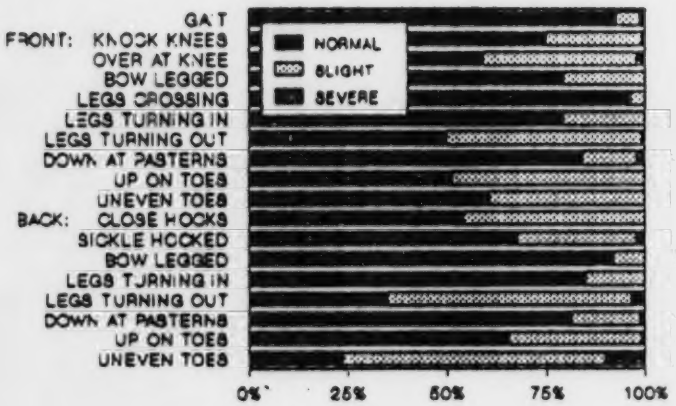


Figure I.3.4 (1b)
Distribution of Day 2 Scores
• Evaluator 1 •

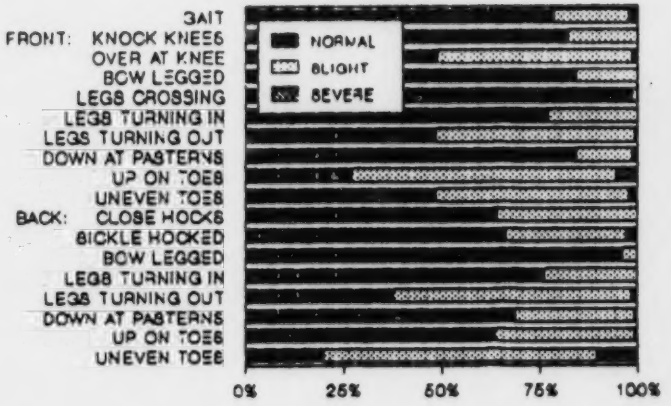


Figure I.3.4 (2a)
Distribution of Day 1 Scores
• Evaluator 2 •

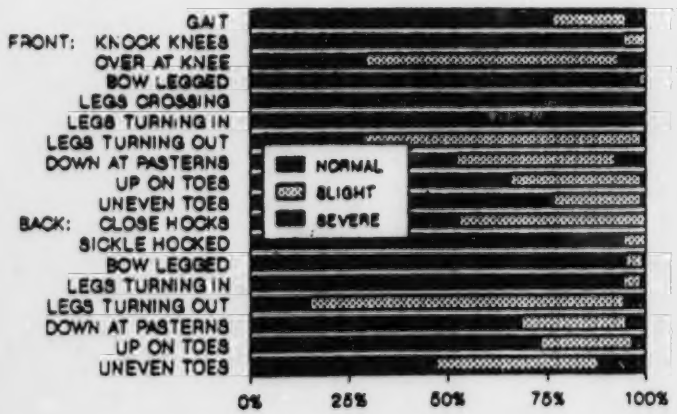


Figure I.3.4 (2b)
Distribution of Day 2 Scores
• Evaluator 2 •

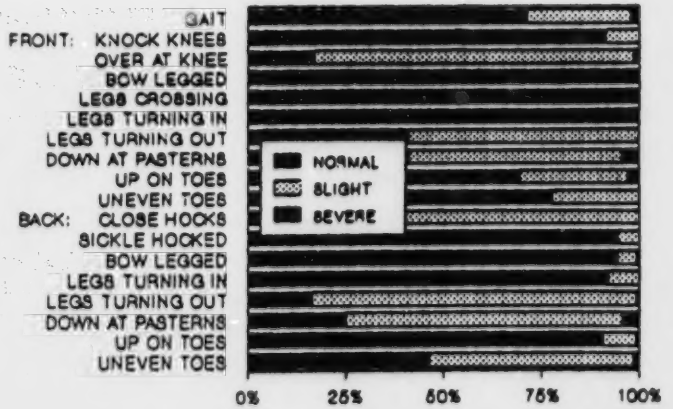


Figure L3.4 (3a)
Distribution of Day 1 Scores
• Evaluator 3 •

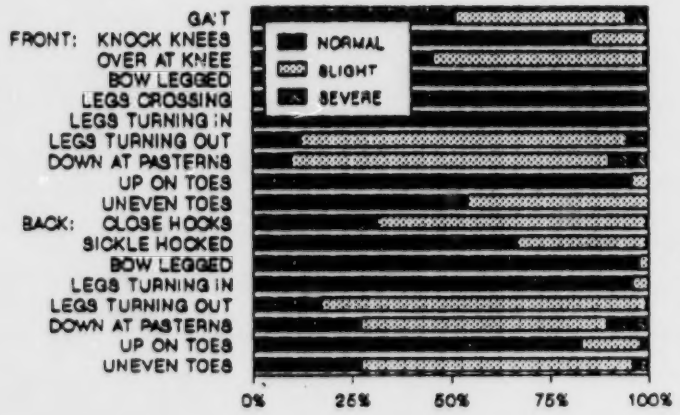


Figure L3.4 (3b)
Distribution of Day 2 Scores
• Evaluator 3 •

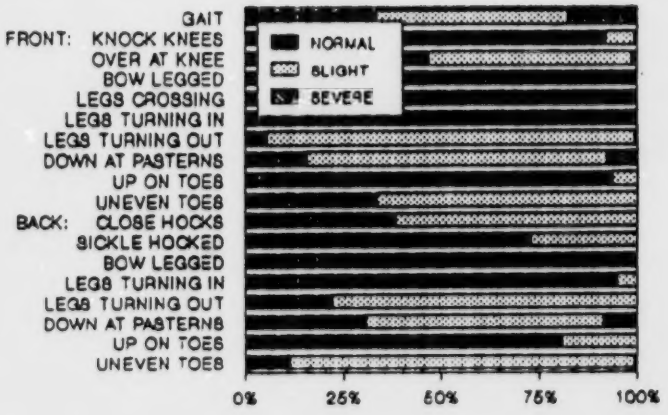


Table 1.3.4 (1)

Repeatability of Feet and Leg Scores

Trait	Repeatability	
	Between Evaluators	Within Evaluator and Pig
Gait	.20	.20
Front Legs:		
Knock kneed	.04	.08
Over at knee	.10	.19
Bow legged	.17	.01
Crossing	.02	.00
Turning in	.21	.00
Turning out	.18	.09
Down at pasterns	.38	.19
Up on toes	.29	.11
Uneveness of toes	.10	.11
Back Legs :		
Closeness of hocks	.06	.08
Sickle hocks	.13	.09
Bow leggedness	.01	.06
Turning in	.06	.14
Turning out	.05	.14
Down at pasterns	.20	.17
Up on toes	.04	.20
Uneveness of toes	.08	.15

I.3.5

RELATIONSHIP BETWEEN FEET AND LEG TRAITS AND PRODUCTIVE LIFETIME

INTRODUCTION

The objective of this study was to derive survival curves for animals distinguished by different feet and leg scores and determine which trait(s), if any, could be used to predict survival or failure due to feet and leg problems.

EXPERIMENTAL DESIGN

Records were available on 1284 Landrace and 794 Large White sows. The sows had been scored for feet and leg structure at the end of performance test, selected and dispatched to either Nucleus or Multiplication herds. Their status was classified as either (1) censored or (2) failed. In this study, censored observations were defined as those animals which were either still in the herd at the end of the experiment/contract on February 1, 1990 and had yet to fail or animals which were removed from the system for other reasons (i.e. repeat-breeder, farrowing difficulty, poor litter size, death, etc.). Failed observations were defined as those animals which had been culled for feet and leg problems. Survival was defined as age (days) to censor or fail. It should be understood that in defining censored and failed observations in this way, the assumption was made that, if given the opportunity, all sows would eventually fail because of feet and leg problems.

The presence of censored observations in lifetime or survival data is a common feature. For such observations, it is only known lifetime exceeded the given value; the exact lifetime remains unknown. The data cannot be analysed by ignoring censored observations because, among other considerations, the longer-lived units are generally more likely to be censored. The analysis must correctly include both censored and non-censored observations (SAS, 1988).

The proportion of females in both censored and failed categories is presented in Table I.3.5 (1) for both breeds. It can be readily seen that a high proportion of the observations were censored; 94.3% in Landrace and 82.2% in Large Whites. The accuracy of survival functions is likely to be affected by such a high proportion of censored observations, but little could be done. The problem, in part, was and is due to the relatively small number of animals culled for feet and leg problems. Ideally, the analysis should be re-run once all sows in the data set have been culled, only then would the true proportion of failures be known.

The LIFETEST procedure (SAS, 1988) was used to analyse the data. The program first estimated survival functions for each strata (score of 0, 1 or 2), and then separate log-rank and Wilcoxon chi-square values for testing whether two or more samples (i.e. pigs scoring 0, 1 or 2) could have arisen from identical survival functions were calculated. The log-rank test places more emphasis on larger survival times whereas the Wilcoxon test places more emphasis on earlier survival times. Aggregate leg score was treated as a covariate and chi-square statistics were computed to determine it's association with survival time.

RESULTS

Log-rank and Wilcoxon chi-square values for feet and leg traits are presented for each breed in Table I.3.5 (2). Probabilities for each chi-square test are superscripted. As an example, if the probability were listed as .05, the there was a 95% chance that differences observed between strata (scores of 0, 1 or 2) were real differences and not simply due to chance differences in sampling.

Significant differences in survival curves of Landrace sows were noted for the traits 'down at pasterns' in the front legs, 'closeness of hocks' in the back legs and 'up on toes' in the front and back legs. With the exception of 'down at pasterns', sows assigned moderate scores in any of the aforementioned categories were more likely to fail (i.e. be culled for feet and leg problems). Conversely, when compared to sows assigned normal scores for 'down at pasterns' in the front legs, those assigned moderate scores were less likely to fail. This is not surprising in view of the significant differences observed for 'up on toes'. In visualizing the stance of a pig considered to be up on it's toes, it's difficult to imagine how that same pig could also be considered down on it's pasterns. Structurally, one would expect a moderate score in 'up on toes' to preclude a moderate score in 'down at pasterns', and vice versa. Survival curves for 'up on toes' in the front and back legs, 'down at pasterns' in the front legs and 'closeness of hocks' in the back legs are presented in Figures I.3.5 (1a, 1b, 1c and 1d).

As with Landrace sows, differences in scores (0 vs 1) for 'up on toes' in in the front and back legs and 'closeness of back hocks' were seen to significantly affect survival curves of Large White pigs. And, although survival distributions for 'down at pasterns' were not significantly different in the front legs, they were in the back legs. With the exception of 'down at pasterns', a greater percentage of sows assigned moderate scores were likely to fail at a younger age. Survival curves for these four traits are presented in Figures I.3.5 (2a, 2b, 2c and 2d).

For both Landrace and Large White sows, aggregate leg score was not seen to significantly affect survival distributions.

SUMMARY

Although there are a number of difficulties inherent to this type of analysis and the reader is cautioned to bear these in mind when interpreting the results, several observations merit further consideration. Namely, a significant difference between survival of sows assigned moderate scores for 'up on toes' in the front and back legs and 'close back hocks' and those assigned normal scores for these three traits. The latter group had proportionately greater survival times.

REFERENCES

SAS Institute Inc. 1988. LIFETEST procedure; Technical Report P-179, Additional SAS/STAT Procedures, Release 6.03, Cary, NC. pp 49-90.

Table 1.3.5 (1)
Distribution of censored and failed observations

		Landrace		Large White	
		Censored	Failed	Censored	Failed
Gait	0	126	11	159	22
	1	1065	63	531	80
	2	18	1	2	0
Front legs:					
knock knees	0				
	1				
	2				
over at knee	0	280	17	208	34
	1	905	57	477	67
	2	24	1	7	1
turning out	0	307	13	198	27
	1	895	62	491	75
	2	7	0	3	0
down at pasterns	0	341	29	257	49
	1	797	43	428	52
	2	71	3	7	1
up on toes	0	1084	63	595	79
	1	125	12	97	23
	2	0	0	0	0
uneveness of toes	0	491	29	292	43
	1	717	46	400	59
	2	1	0	0	0
Back legs :					
closeness of hocks	0	411	24	357	42
	1	796	51	334	60
	2	2	0	1	0
sickle hocks	0	256	20	237	35
	1	890	53	448	67
	2	63	2	7	0
turning out	0	188	13	139	13
	1	1016	61	553	89
	2	5	1	0	0
down at pasterns	0	361	29	313	60
	1	831	46	372	42
	2	17	0	7	0
up on toes	0	1077	61	565	73
	1	132	14	126	29
	2	0	0	1	0
uneveness of toes	0	197	7	207	27
	1	1007	68	484	75
	2	5	0	1	0

Table 1.3.5 (2)
Chi-square values for testing equality over strata[a]

	Landrace				Large White			
	Log-rank test		Wilcoxon test		Log-rank test		Wilcoxon test	
Gait	.0233	.99	1.1369	.57	.8482	.65	.6950	.71
Front legs :								
knock knees								
over at knee	.1434	.93	.0834	.96	.1748	.91	1.3744	.50
turning out	.4503	.80	.3346	.85	.7094	.70	.7348	.69
down at pasterns	4.1709	.12	3.6216	.16	2.9549	.22	1.0452	.59
up on toes	3.5237	.06	3.0232	.08	6.6165	.01	2.2968	.12
uneveness of toes	.4165	.81	.1518	.93	.0902	.76	.1483	.70
Back legs :								
closeness of hocks	3.6577	.16	3.3555	.19	8.1357	.02	7.3484	.03
sickle hocks	.9311	.63	.7400	.69	.7155	.70	.7285	.70
turning out	1.7828	.41	.0199	.99	2.0081	.16	.8310	.36
down at pasterns	1.2221	.54	1.1400	.57	4.7077	.10	5.0362	.08
up on toes	1.3243	.25	2.4991	.11	4.5214	.10	4.3725	.11
uneveness of toes	.8525	.65	.8721	.65	.2118	.90	.3094	.86
Aggregate leg score[b]	.5885	.44	.5631	.45	1.3018	.25	1.1641	.28

[a] strata defined as scores of 0, 1 or 2
chi-square values superscripted by probability that differences between strata were true differences (i.e. significant) and not simply due to chance differences in sampling.

[b] analysed as a covariate (no strata)

Figure I.3.5 (1a)
Survival Distribution for Landrace
* Up on Toes in the Front Legs *

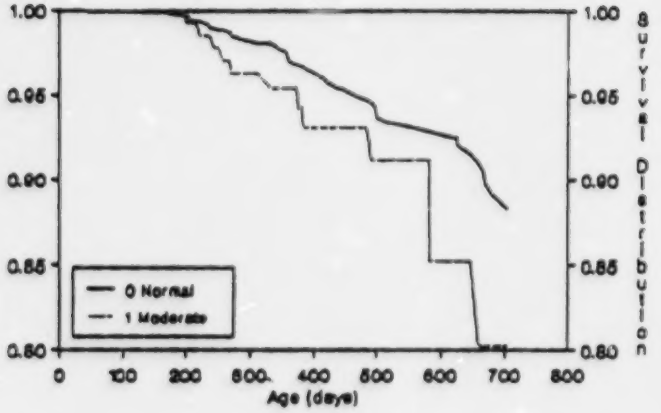


Figure I.3.5 (1b)
Survival Distributions for Landrace
* Closeness of Hocks in the Back Legs *

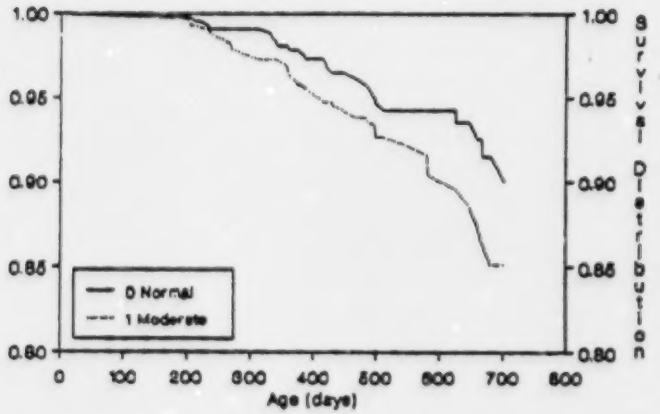


Figure I.3.5 (1c)
Survival Distributions for Landrace
* Up on Toes in the Back Legs *

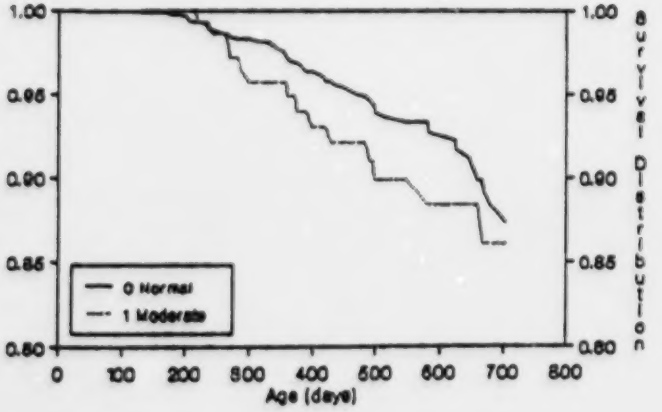


Figure I.3.5 (1d)
Survival Distribution for Landrace
* Down at Pasterns in the Front Legs *

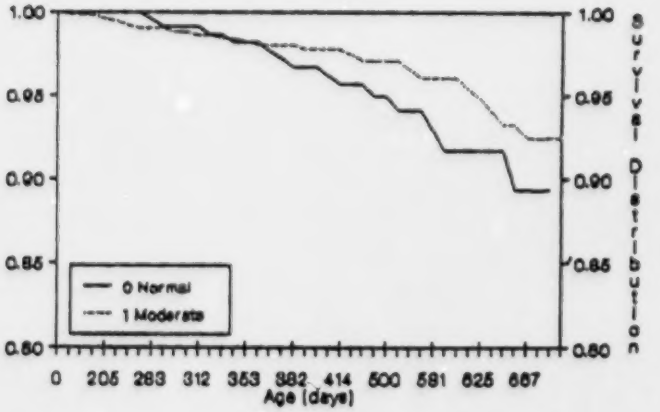


Figure I.3.5 (2a)
Survival Distributions for Large White
* Up on Toes in the Front Legs *

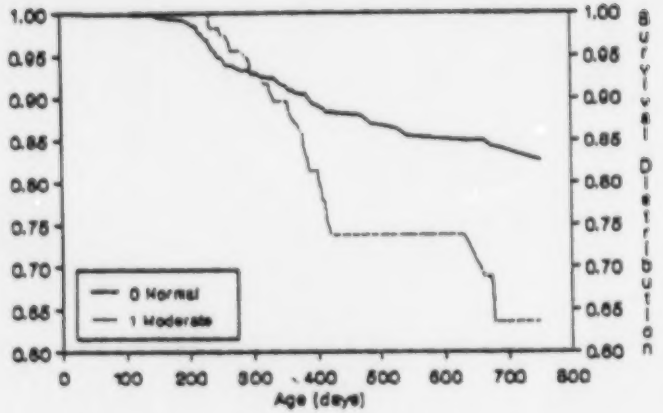


Figure I.3.5 (2b)
Survival Distributions for Large White
* Closeness of Hocks in the Back Legs *

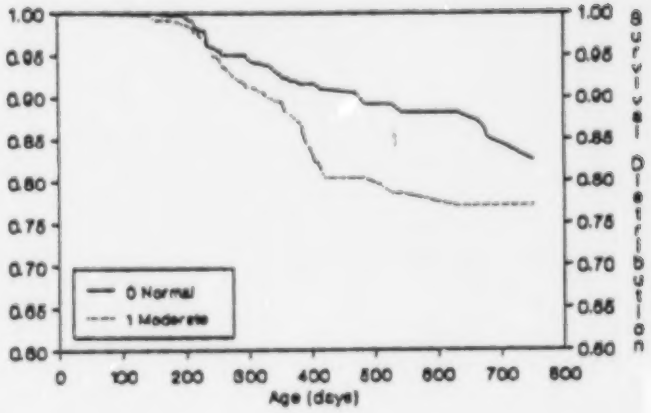


Figure I.3.5 (2c)
Survival Distributions for Large White
* Up on Toes in the Back Legs *

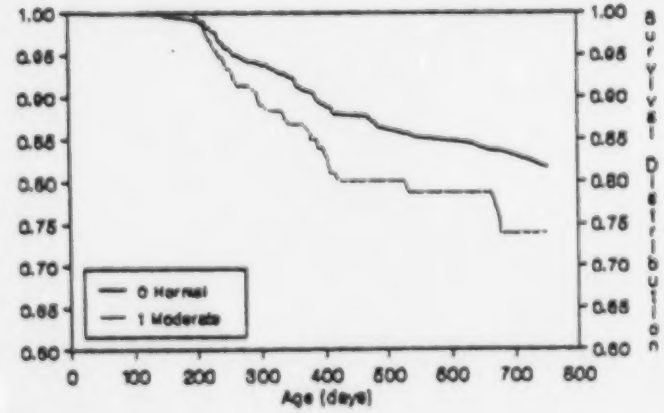
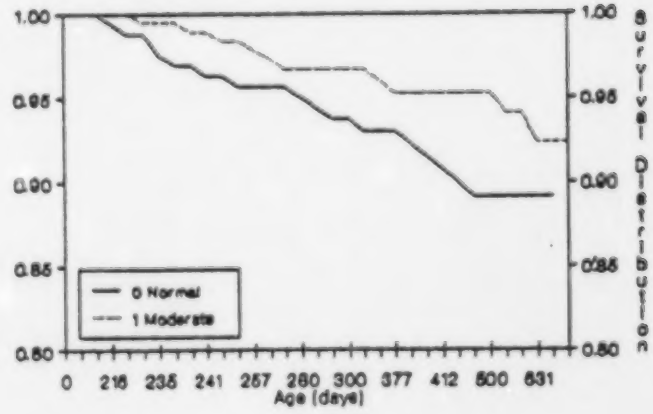


Figure I.3.5 (2d)
Survival Distributions for Landrace
* Down at Pasterns in the Back Legs *



I.3.6

SUMMARY OF FEET AND LEG CULLS IN THE MULTIPLICATION SYSTEM

INTRODUCTION

The purpose of this section was to demonstrate that, over the term of the projects, a structurally improved breeding animal has been developed which can function in a variety of management conditions.

EXPERIMENTAL DESIGN

Between April 1987 and February 1990, sow cull information from 10 Landrace and 8 Large White Multiplication herds, representing a variety of management conditions, was collected. EASICARE 'Sow Leavers Analysis' was used to determine the number of sows culled for feet and leg problems as a percentage of total culls and average number of sows for each contract year. Average parity of sows culled for feet and legs was also determined.

RESULTS

Results are presented in Table I.3.6 (1). The average number of sows in Multiplication increased approximately 2.5 times over the course of the project. And, although the percentage of Landrace sows culled for feet and leg problems showed little improvement over the three years, the average parity at which these sows were culled did show considerable improvement, increasing from 1.39 in the first year to 2.15 in the last year. Conversely, the average parity for feet and leg culls in Large White's fluctuated from year to year, yet the percentage of Large White sows culled for feet and legs, both as a percentage of total culls and average number of sows, improved each contract year.

SUMMARY

In a dynamic system such as this one, where new herds are continually being added, it is difficult to quantify change. Nevertheless, it would appear the challenge of providing a structurally improved breeding animal capable of surviving in a variety of management conditions has met with some success.

REFERENCES

Easicare Computers Ltd. 1981. Easicare Pig Data Systems (Program). Upton House, Beeford, Driffield, East Yorkshire, YO25, 8AF, England.

Table 1.3.6 (1)

Summary of feet and leg culls in the Multiplication system

	Contract Year		
	1	2	3
Average number of sows			
Landrace	649	1172	1646
Large White	376	729	999
Number of sows culled for feet and leg problems			
Landrace	54	90	145
Large White	53	84	79
Feet and leg culls / total culls (%)			
Landrace	29.67	23.50	31.32
Large White	25.98	23.93	16.46
Feet and leg culls / average number of sows (%)			
Landrace	8.32	7.68	8.81
Large White	14.10	11.52	7.71
Average parity of sows culled for feet and legs			
Landrace	1.39	1.96	2.15
Large White	1.72	1.23	1.59

II.1

CONTRACT

OBJECTIVE

Research and develop a highly prolific breeding female capable of rearing large numbers of progeny under variable management conditions.

BACKGROUND AND RATIONALE

Prolificacy

A need exists to improve the prolificacy of animals in the Provincial and National Breeding herds as a number of pigs produced per unit of production is the foundation of successful pig keeping. Our better producers are marketing over 20 pigs/sow/year under excellent management. A need exists for a genetically improved female to perform well under sub-optimal or variable management situations.

ACTION PLAN

a) Current Base Line 9.3 born alive 1.00 born dead
10.3 total born

		Pigs Improvement	Total Born
Goals :	March 31, 1988	0.0	10.30
	March 31, 1989	+0.25	10.55
	February 1, 1990	+0.25	10.80

b) Genetic improvements in Nucleus operation and passed onto crossbred gilts. See Tables II.1 (1) and (2).

Table II.1 (1)
Comparison of various crossbreeding systems[1]

System	Slaughter pig	Pigs/litter	% of purebreeding	Genetic lag (yrs)
1. Purebreeding A, B	AA or BB	8.3	100	3.75
C	CC	7.3	88	3.75
2. Purebred sow - crossbred litter	AB	8.8	106	3.75
3. Firstcross sow - backcross litter	A(BA) or B(AB)	9.3	115	2.62
4. Sireline boar on firstcross sow	C(AB)	9.6	118	2.62
5. Backcross sow to grandsire boar	B(A(BA))	9.0	110	3.19
6. Backcross sow to sirebreed boar	A(A(BA)	8.8	107	3.19
7. Backcross sow to sire line boar	C(A(BA)	9.2	112	3.19
8. 2 breed criss-cross	B(A(B(AB)))	9.1	112	3.75
9. 3 breed rotation cross	B(A(C(AB)))	9.0	111	3.75
10. Sireline boar - criss-cross sow	C(A(B(AB)))	9.3	114	3.38

[1] Adapted from Bichard, M. 1977. Economic Efficiency of Pig Breeding Schemes: A Breeding Company Review. Livest. Prod. Sci., 4:245-254.

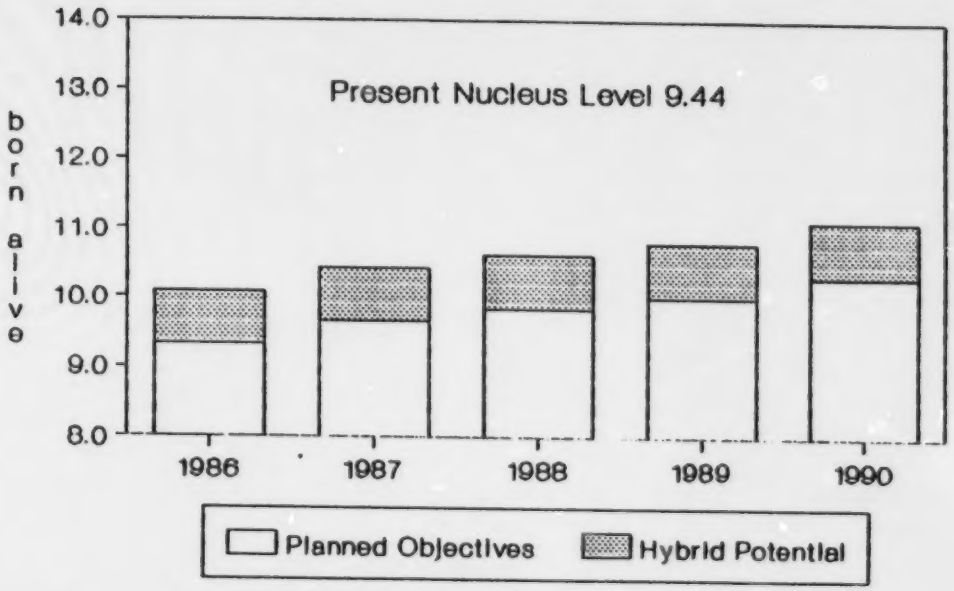
Assumptions:

* Pigs per litter for 1, 2, 3 are assumed, the remainder predicted
* Individual heterosis = .5 pigs per litter
* Maternal heterosis = .75 pigs per litter and 15% reduction in weaning to breeding interval
* 2.2 litters per sow per year from purebreds
* Average merit gilts and boars passed down
* Boars kept 1 year, sows for 5 litters

The hybrid female must be mated to a selected boar of good quality to produce the high quality pigmeat demanded by the consumer.

The project design is planned on the direction in which the pig industry is progressing using the resources and superior animal within the N.P.D. system. The final product will be a selected hybrid female and a selected, tested boar.

Table II.1 (2)
Litter Size Improvements from Purebred and Potential Hybrid Improvement



II.2
REALIZATION OF ACTION PLAN

a) Contract

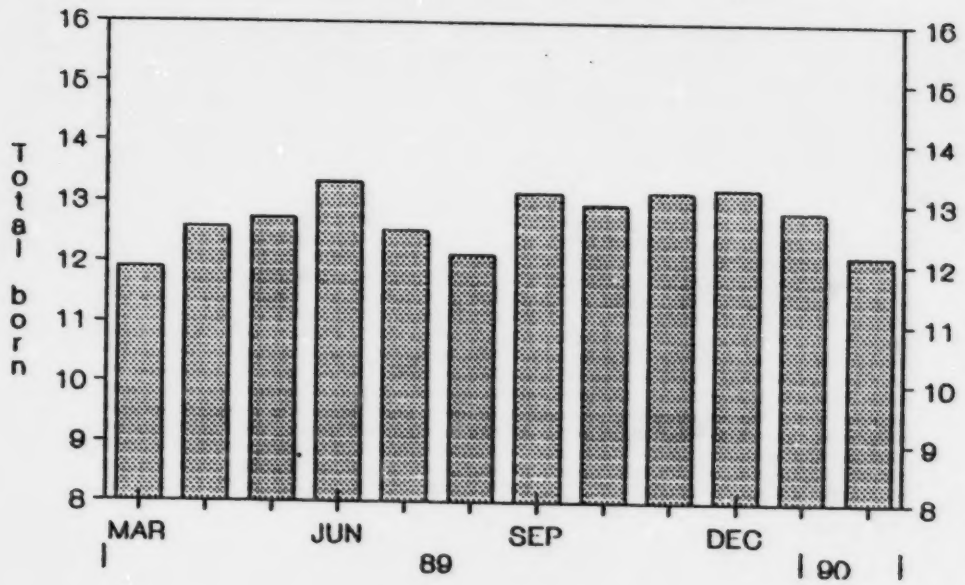
	Contract	Actual	Contract - Actual
Apr 87 - Mar 88	10.30	9.85	-0.45
Landrace		10.70	
Large White		9.16	
Apr 88 - Mar 89	10.55	10.21	-0.34
Landrace		10.74	
Large White		9.71	
Apr 89 - Feb 90	10.80	10.30	-0.50
Landrace		10.79	
Large White		9.84	
Improvement	0.50	0.45	

For reasons already mentioned in section I.2, original contract values used as a reference to derive annual goals were different than values at the time the contract was initiated. Although contract target values were never met, an increase in litter size in both breeds was noted over the term of the project. Using actual values, an average improvement of .45 pigs/litter was observed.

b) Genetic improvement in Nucleus operation passed on to crossbred gilts.

At present, only a single, 155 Manor Hybrid commercial unit is recording information through the company's EASICARE software systems. Average born for the year ending February 1990 was 12.7 pigs. Monthly averages for the year are plotted in Figure II.2 (1).

Figure II.2 (1)
Average Litter Size of Crossbred Females
• Single Commercial Unit •



II.3
RESEARCH PROJECTS

II.3.1 GENERAL INTRODUCTION

Despite the low heritability of prolificacy in pigs, most researchers agree genetic progress is possible. It can be achieved in any of three ways:

(1) selection within chosen breeds or lines
(2) selection between breeds or lines
(3) selection among different crossbreeding systems

Although within-breed or line selection is the most tedious option, it offers the greatest potential for continued long-term improvement. It requires the application of consistent and sound selection techniques in a very large population for a number of generations (Bichard and David, 1985). Progress would be slow and selection for growth and carcass traits may be compromised (Ollivier, 1982).

Over the term of the contract, the Nucleus unit was comprised of approximately 270 Landrace and 270 Large White sows. Although large by some standards, there were simply not enough sows to justify implementation of a hyper-prolific breeding program. Such a program was initiated several years ago in the parent company N.P.D. (United Kingdom) and, with over 2000 sows in Nucleus, has met with reasonable success. For the most part, the improvements noted in the N.P.D. (Canada) Nucleus were likely attributable to introduction of external stock, changes in management practices and environment.

For reasons outlined, the relevance of genetic improvements in litter size due to within-breed selection was of limited consequence in this project. Estimates of genetic parameters of sow productivity were computed, as a matter of interest, and are presented in section II.3.2. The research projects were focused on the effects of new sire lines (II.3.3), age to first service (II.3.4), number of matings per services (II.3.5) and sow condition (II.3.6) on litter size.

Most efforts to improve prolificacy have concentrated on various cross-breeding systems which, in most instances, results in the greatest improvement per unit time. The use of crossbred females takes advantage of the benefits arising from heterosis, estimated at between 8% and 15% (Johnson, et al., 1984). N.P.D.'s dam line, the MANOR HYBRID, is an F1 crossbred gilt. Performance of this crossbred female was referenced in section II.2, part b. Crossing of two

genetically different lines of pigs of the same breed tends to increase genetic variability and often progeny exhibit heterosis. A program to introduce external, unrelated stock was initiated and it's results are discussed in section IV.1 titled "A.I. Program". Trends in litter size of Nucleus and Multiplication herds is provided in section II.3.7.

REFERENCES

Bichard, M. and David, P.J. 1986. Producing more pigs per sow per year - genetic contributions. J. Anim. Sci. 63:1275-1279.

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II.3.2
GENETIC AND PHENOTYPIC PARAMETERS OF LITTER TRAITS

INTRODUCTION

The objective of this exercise was to examine the effect of parity on litter size, and estimate heritability and repeatability of litter traits.

EXPERIMENTAL DESIGN

Litter records, based on 1986 through 1990 farrowings, were collected on 521 Landrace and 589 Large White sows. Only records of sires with a minimum of 3 daughters in the herd were retained. Data were also limited to first through fifth parity records. A summary of the data used in the analysis is presented in Table II.3.2 (1). Traits included were total born, number born live and total litter weight. Means and standard deviations for each trait are given in Table II.3.2 (2) for Landrace and Large White sows.

Data were analysed using a single-trait, restricted maximum likelihood program written by Meyer (1987). Analyses were carried out separately for each breed using the following model:

$$y_{ijkl} = u + b_1 X_{1ijkl} + parity_i + sire_j + dam_{jk} + error_{ijkl}$$

y_{ijkl}	is an observation on the $ijkl^{th}$ litter,
u	is the population mean,
$b_1 X_{1ijkl}$	is the regression of litter trait on age at first effective service,
$parity_i$	is the fixed effect of the i^{th} parity, i = 1, 5,
$sire_j$	is the random effect of the j^{th} sire of dam_{jk} (= maternal grandsire of litter), $N(0,V_s)$,
dam_{jk}	is the random effect of the k^{th} dam, nested within the j^{th} sire, $N(0,V_d)$,
$error_{ijkl}$	is the random error associated with an observation on the $ijkl^{th}$ litter, $N(0,V_e)$.

Based on farrowing date, two seasons, over a 4.5 year period, were defined for a total of 9. Farrowings between April and November were assigned as season 1, while farrowings which occured between November and March were assigned as season 2. Sire and dam variance components were assumed to contain 1/4 of the additive genetic variation. Dam variance components were also assumed to contain dominance and maternal effects. Heritability of litter traits was calculated as $(4.0 * V_s) / (V_s + V_d + V_e)$. Repeatabilities were estimated as $(V_s + V_d) / (V_s + V_d + V_e)$.

RESULTS

The relative effect of parity on litter traits is presented in Table II.3.2 (3). The regression of age at first service on litter traits was not found to be significant and was excluded from the report. For each trait, the mean of first parity traits was set to 0.0 and values for 2nd through 5th parities represent deviations from that mean. These deviations are the best linear unbiased estimates of the difference between 1st and other parities. For example, relative to 1st parity litters, 2nd parity litters had .40 less pigs born, .07 less pigs born alive and a total litter weight of .11 kg less.

A second litter "drop" of .40 pigs/litter and .35 pigs/litter was observed in Landrace and Large White sows, respectively. The "drop" was less noticeable when only pigs born live were considered. With fewer pigs born live in the 2nd litter, a corresponding decrease in litter birth weight was noted. In both breeds, total pigs born peaked in the 3rd litter but the trend was not substained in subsequent 4th and 5th parities.

Variances, heritability and repeatability of litter traits are reported in Table II.3.2 (4). The low heritabilities and repeatabilities of litter traits computed in this study were consistent with literature estimates (Gu et al., 1989). Heritability of total born and pigs born live was considerably lower in Large White pigs compared to Landrace. Alternately, repeatability of these trait was higher in Large White's due to proportionately higher dam variance components. The implication is that selection for increased litter size would be slower, while litter size over parities would be expected to be more consistent in Large White's when compared to Landrace.

SUMMARY

Total born, pigs born live and litter birth weight were found to be lowly heritably (12% or less) and only moderately repeatable (6% - 21%).

REFERENCES

Gu, Y., Baley, C.S. and Thompson, R. 1989. Estimates of genetic and phenotypic parameters of litter traits from closed lines of pigs. Anim. Prod. 49:477-482.

Meyer, K. 1987. Restricted Maximum Likelihood (REML) programs for the analysis of animal breeding data. Institute of Animal Genetics, Edinburgh University, Scotland.

Table II.3.2 (1)

Data summary

	Landrace	Large White
Number of:		
Sires	53	55
Dams	521	589
Year-seasons	9	9
Records	1155	1219

Table II.3.2 (2)

Means and standard deviations of litter traits

	Landrace		Large White	
	Mean	s.d.	Mean	s.d.
Total born	10.48	2.88	9.27	2.81
Born live	9.55	2.79	8.52	2.72
Litter weight (kg)	13.90	4.38	12.44	4.24

Table II.3.2. (3)

Relative effect of parity on litter traits

		Landrace			Large White		
	Parity	No.	Mean	s.e.	No.	Mean	s.e.
Total born	1	521	.00		589	.00	
	2	291	-.40	.16	297	-.35	.14
	3	182	.52	.20	194	.37	.18
	4	114	.40	.25	104	.13	.24
	5	47	.36	.39	35	-.64	.42
Born live	1	521	.00		589	.00	
	2	291	-.07	.16	297	-.27	.14
	3	182	.48	.20	194	-.01	.18
	4	114	.16	.25	104	-.39	.24
	5	47	.19	.39	35	-1.03	.42
Litter weight (kg)	1	521	.00		589	.00	
	2	291	-.11	.24	297	-.08	.22
	3	182	.94	.31	194	.16	.27
	4	114	-.35	.39	104	-.72	.37
	5	47	-.52	.60	35	-1.67	.64

Table II.3.2 (4)

Variances, heritability and repeatability of litter traits

		Total born	Born live	Litter weight (kg)
Landrace	V_s	.2487	.0414	.1478
	V_d	.9535	.8193	1.0193
	V_e	7.0337	6.9205	17.1057
	heritability	.12	.02	.03
	repeatability	.15	.11	.06
Large White	V_s	.1254	.0195	.2894
	V_d	1.5232	1.3719	2.4172
	V_e	6.1405	6.0193	14.4411
	heritability	.06	.01	.07
	repeatability	.21	.19	.16

II.3.3

CONCEPTION RATES AND LITTER SIZES OF A.I. AND N.P.D. BOARS

INTRODUCTION

Regular introductions of external, unrelated stock help maintain genetic diversity which is essential for selection and continued improvement.

Between October 1987 and August 1989, N.P.D. (Canada) sampled a number of top A.I. boars from the Alberta and Ontario A.I. centres. A summary of conception rates and litter sizes of these A.I. boars, as well as N.P.D. boars in service at the same time, is provided in this report.

EXPERIMENTAL DESIGN

A total of 12 Landrace and 16 Large White A.I. boars were sampled. The semen, transported via air to Saskatoon, Saskatchewan and ground to the Nucleus in Humboldt, Saskatchewan, was used within 8 hours of delivery.

Service history, by boar origin, is presented in Table II.3 (1). Conception rates of A.I. boars was quite good, ranging from 78.4% through 82.9% and averaging 80.7%. Success rates of natural N.P.D. matings averaged 90.3% for both breeds.

Records were available on 1073 Landrace litters, of which 102 were sired by A.I. boars, and 1182 Large White litters, of which 89 were sired by A.I. boars. The effect of boar origin on litter size was investigated for each breed using the following model for analysis:

$$y_{ijklm} = u + parity_i + season_j + source_k + sire_{lk} + e_{ijklm}$$

where

y_{ijklm}	is the litter size of the $ijklm^{th}$ sow,
u	is the population mean,
$parity_i$	is the fixed effect of the i^{th} parity,
$season_j$	is the fixed effect of the j^{th} season (month-year) of breeding
$source_k$	is the fixed effect of the k^{th} source of service (AI, NPD),
$sire_{kl}$	is the fixed effect of the l^{th} sire, nested within the k^{th} source, and
$error_{ijklm}$	is the random error associated with an observation on the $ijklm^{th}$ sow, $N(0,V_e)$.

RESULTS

Average litter sizes, by breed and boar origin, are included in Table II.3.3 (2). A.I. Landrace sired litters were slightly larger at 10.62 pigs compared to litters of naturally mated Landrace sows which averaged 10.49 pigs, but the difference was not significant. Large White litters by A.I. boars were considerably smaller, averaging .78 pigs less per litter when compared to litters sired by N.P.D. boars. Differences were significant at P = 13.6%.

SUMMARY

For a 22 month period, beginning October 1987, the N.P.D. Nucleus sampled 28 A.I. boars from the Ontario and Alberta studs. Approximately 10% of all matings in the herd were A.I with an average conception rate of 80.7%. To date, 191 A.I. litters have been born. Litter sizes were slightly better in Landrace but poorer in large Whites. These A.I. progeny will be performance tested alongside N.P.D. pigs and superior individuals included in the N.P.D. breeding pyramid.

Table II.3.3 (1)
Conception rates of A.I. and N.P.D. boars

	Landrace			Large White		
	no.	total services	% conception	no.	total services	% conception
A.I.	12	135	83.0	16	139	78.4
N.P.D.	49	1163	89.9	62	1264	90.7

Table II.3.3 (2)
Litter size of A.I. and N.P.D. boars

	Landrace			Large White		
	no.	litter size	s.e.	no.	litter size	s.e.
A.I.	102	10.62	.32	89	8.60	.31
N.P.D.	971	10.49	.10	1093	9.38	.09

II.3.4
EFFECT OF AGE AT FIRST BREEDING ON LITTER SIZE

INTRODUCTION

A number of researchers have reported increases in ovulation rate over successive estrous periods (Young and King, 1981; Paterson and Lindsay, 1980), and particularly in gilts reaching puberty at young ages (5 to 7 months) (Kirkwood and Aherne, 1985). As such, delaying service in certain populations of gilts would be expected to yield an increase in litter size.

The objective of this study was to determine the effect of delaying first service in N.P.D. Nucleus Landrace and Large White gilts on litter size.

EXPERIMENTAL DESIGN

To establish whether trends in litter size and age at 1st service were evident within the N.P.D. system, information, gathered between April of 1987 and February 1990, was plotted. Following this, a program to delay first service in Nucleus gilts to approximately 8 months of age was implemented between January and June of 1989.

Within year regressions of litter size on age at 1st service were computed for the 6 month period ending June of 1989 and compared to similar regressions for 1987 and 1988. Data were analysed separately for each breed and year using SAS's GLM procedure (1985) according to the following model:

$$y_{ijk} = u + b_1X_{1ijk} + sire_i + dam_{ij} + error_{ijk}$$

where

y_{ijk}	is the litter size of the ijk^{th} gilt,
u	is the population mean,
b_1X_{1ijk}	is the regression of litter size on age at first service (days),
$sire_i$	is the random effect of the i^{th} sire of gilt, absorbed, $N(0,V_s)$,
dam_{ij}	is the random effect of the j^{th} dam of gilt, nested within the i^{th} sire, absorbed, $N(0,V_d)$,
$error_{ijk}$	is the random error associated with an observation on the ijk^{th} gilt, $N(0,V_e)$.

RESULTS

Average age at first breeding and litter size were plotted for each N.P.D. Landrace and Large White Multiplication unit (see Figures II.3.4 (1a) and (1b)). There was evidence that units which tended to breed at later ages also tended to farrow larger litters. Within the range reported, 200 through 250 days at first breeding, regressions of litter size on age at 1st breeding were computed. They revealed an increase of .22 pigs/litter in Landrace units and .12 pigs/litter in Large White units for every increase of 10 days in age at 1st breeding.

Means and standard deviations for litter size and age at first service are presented in Table II.3.4 (1) for each breed and year. For 1987, 1988 and the first half of 1989, average age at first service was 206, 223 and 254 days for Landrace and 209, 228 and 253 days for Large Whites, respectively. Litter size was consistent over the years for Landrace at 10.5 pigs/litter. Considerable variation was noted in Large Whites. Litter size was higher in the second year but decreased in 1989.

Individual regressions for litter size on age at 1st breeding for each year and breed are presented in Table II.3.4 (2). None of the regressions were significantly different from 0.0. Mercer (1987), also noted small and sometimes negative within-herd regressions, speculating that, regardless of average age at 1st service in the herd, gilts which had reproductive problems, either coming later into estrus, or returning to service, also tended to have poorer litters which affected the within-herd regressions. The experiment was further complicated by the fact that although the trial to delay service was not formally instigated until January of 1989, age at first service had been steadily climbing over the previous three years. This effectively nullified any attempts to compare two distinct management practices, service at 215 days versus service at 240 days, within the same herd. Nevertheless, trends in litter size corresponding with ages at first breeding would be expected to provide some insight as to the "optimum" first service age for the Nucleus.

Advancing age to first breeding past 240 days in the Nucleus unit did not offer an advantage in litter size, in fact the reverse seemed to be true in the case of Large Whites (see Figures II.3.4 (2a) and (2b)). Performance of Landrace gilts was consistent across the years, confirming the perception that they are very tolerant and adaptable to management changes. Litter size of Large Whites was highest in the second year when average age at first breeding was 228 days. In this unit, there was no advantage to delaying service beyond this point. Yet, examination of average litter size of Multiplication units differing in the age at 1st service showed a positive relationship.

SUMMARY

Generally speaking, units which had higher ages at first service tended to farrow larger gilt litters. The attempt to delay service to 240 days in the Nucleus unit and observe an increase in litter size was not successful; there seemed no point in delaying service beyond 230 days. In retrospect, a program to delay first service to 230 days, rather than 240, should have been implemented for at least a year in several units which normally served gilts at younger ages.

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Mercer, J.T. 1987. The relationship between age at first effective service and numbers born in the gilt litter in purebred pigs. Paper no. 101. N.P.D. (UK), Manor House, Beeford, Driffield, N. Humberside, YO25 8BD.

Paterson, A.M. and Lindsay, D.R. 1980. Induction of puberty in gilts. Anim. Prod. 31:291.

Young, L.G. and King, G.J. 1981. Reproductive performance of gilts bred on first versus third estrus. J. Anim. Sci. 42:1133.

Figure II.3.4 (1a)
Age at First Service and Litter Size
• Landrace Multiplication Units •

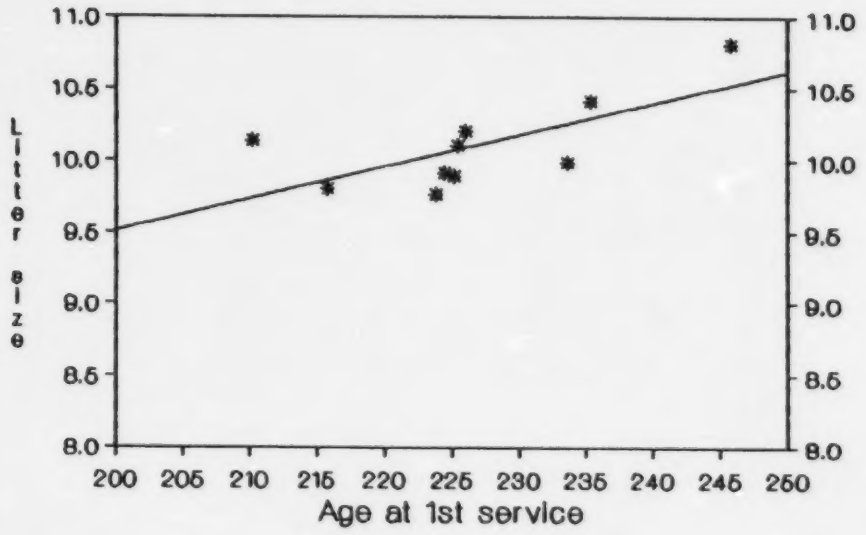


Figure II.3.4 (1b)
Age at First Service and Litter Size
• Large White Multiplication Units •

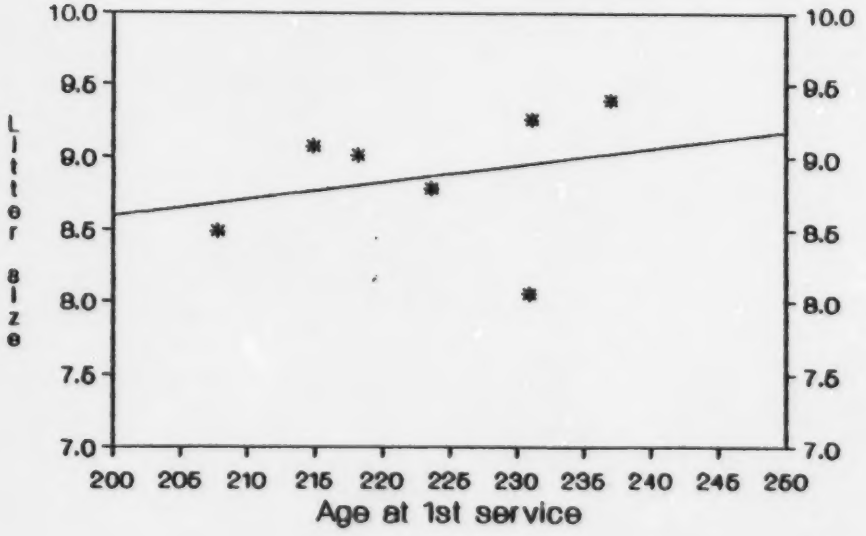


Figure II.3.4 (2a)
Age at 1st Service and Litter Size
• Nucleus Landrace Gilts •

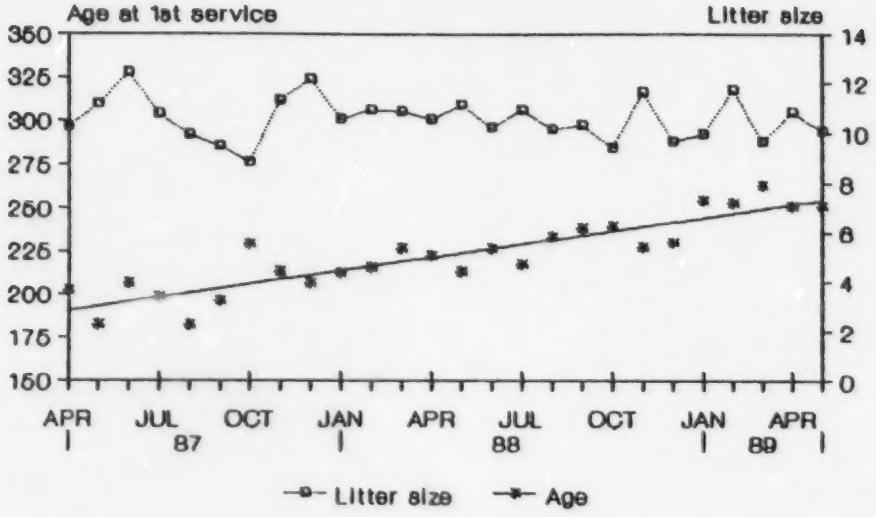


Figure II.3.4 (2b)
Age at 1st Service and Litter Size
• Nucleus Large White Gilts •

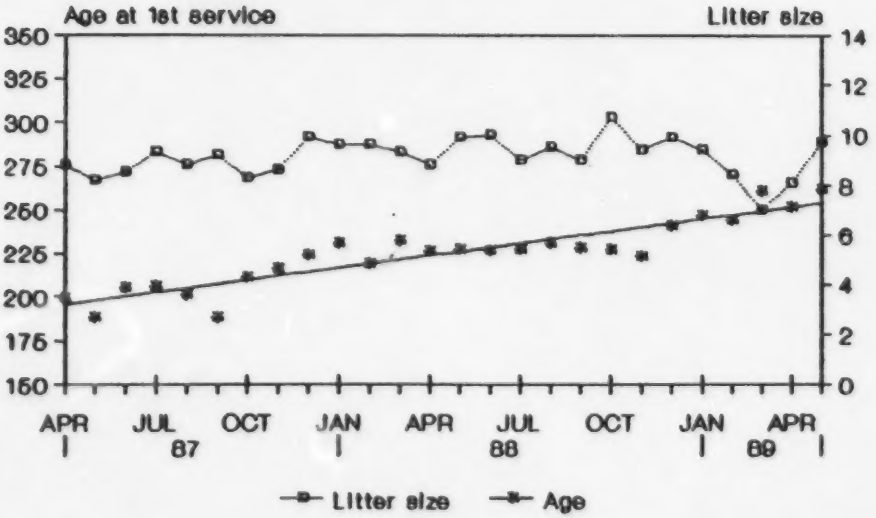


Table II.3.4 (1)

Means and standard deviations of litter size and age at first service

	Landrace					Large White				
		Service Age (days)		Litter Size (no.)			Service Age (days)		Litter Size (no.)	
	No.	Mean	s.d.	Mean	s.d.	No.	Mean	s.d.	Mean	s.d.
Jan 87 - Dec 87	125	206	26	10.5	2.57	212	209	27	8.8	2.59
Jan 88 - Dec 88	152	223	24	10.5	2.42	172	228	25	9.6	2.68
Jan 89 - Jun 89	81	254	25	10.5	2.81	54	253	22	8.5	3.17

Table II.3.4 (2)

Regression and standard error of litter size on age at first service

	Landrace		Large White	
	slope	s.e.	slope	s.e.
Jan 87 - Dec 87	.0001	.0183	-.0145	.0148
Jan 88 - Dec 88	-.0275	.0281	-.0192	.0379
Jan 89 - Jun 89	-.0020	.0469	.0027	.0702

II.3.5

EFFECT OF NUMBER OF MATINGS PER SERVICE ON CONCEPTION RATE AND LITTER SIZE

INTRODUCTION

The objective of this exercise was examine the influence of number of matings/service on conception rate and litter size.

EXPERIMENTAL DESIGN

Between April 1987 and February 1990, a total of 12,411 service records and 9,776 litter records were collected from 10 Landrace and 8 Large White Multiplication units. The Easicare Consolidation program, in conjunction with Easicare Litter Analysis and Easicare Service Analysis, was used to examine the influence of matings/service on conception rate and litter size.

RESULTS

The average conception rates and litter sizes, combined across units and within breed, for 1, 2 and 3 matings/service are presented in Table II.3.5 (1). Conception rate increased with each mating, up to a maximum of three, in both breeds. And, although conception rates of individual units varied considerably, 16 of the 18 units demonstrated improved conception when using 2 matings/service compared to 1 mating/service. Similarly, 14 of the 18 units, found an advantage in using 3 matings/service instead of 2 matings/service (see Figures II.3.5 (1a) and II.3.5. (1b)).

With the exception of 3 versus 2 matings/service in Landrace, an increased number of matings/service corresponded with an increase in litter size (Table II.3.5 (1)). Figures II.3.5 (2a) and (2b) illustrate the effect of increased number of matings/service on litter size in individual units. As with conception rate, the advantage of 3 matings rather than 2 per service varied considerably between units.

SUMMARY

For both conception rate and litter size, there seemed little value in single matings. A minimum of 2 matings/service is recommended, although additional benefits, particularly in terms of conception rate have been shown with 3 matings/service. It should be remembered however, that the additional benefit of a third service varied substantially from one unit to the next and, if not enough

breeding boars are available, may "strain boar power". Therefore, it would seem appropriate for unit managers to evaluate their own herds and alter their breeding programs accordingly.

Table 11.3.5 (1)

Effect of number of matings/service on conception rate and litter size

	Number of matings/service		
	1	2	3
Conception rate			
No. of records			
Landrace	1154	4038	2268
Large White	958	3324	669
% Conceived			
Landrace	65.7	78.9	82.4
Large White	60.6	72.1	77.9
Litter size			
No. of records			
Landrace	846	3313	1929
Large White	613	2500	575
Total born			
Landrace	10.7	11.1	11.1
Large White	9.6	9.9	10.3

Figure II.3.5 (1a)
Matings/Service and Conception Rate
• Landrace Multiplication Units •

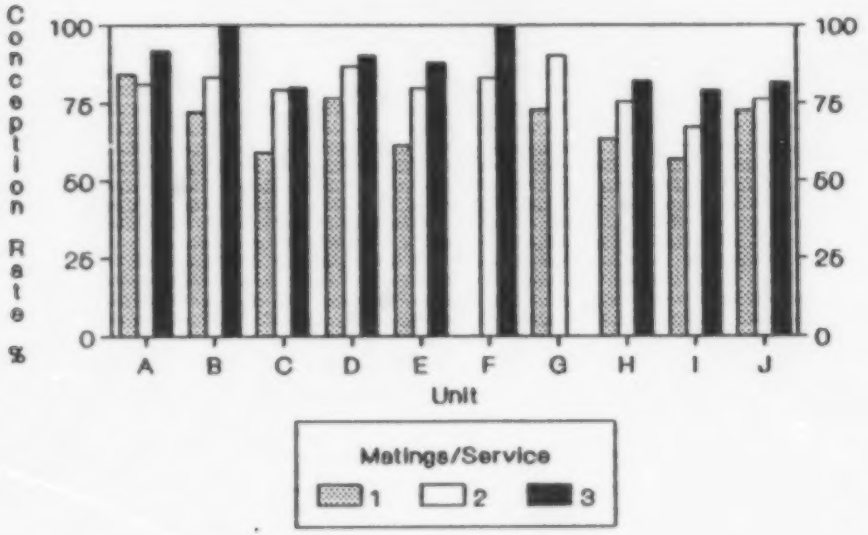


Figure II.3.5 (1b)
Matings/Service and Conception Rate
• Large White Multiplication Units •

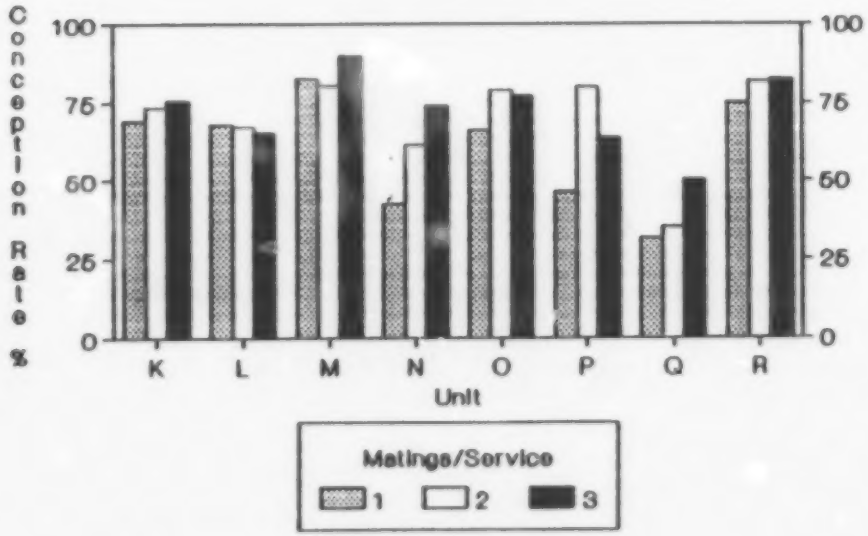


Figure II.3.5 (2a)
Matings/Service and Litter Size
• Landrace Multiplication Units •

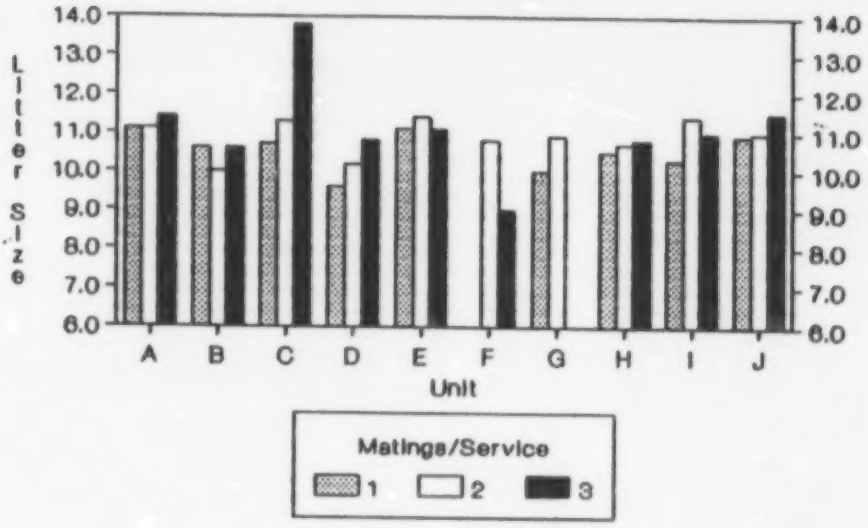
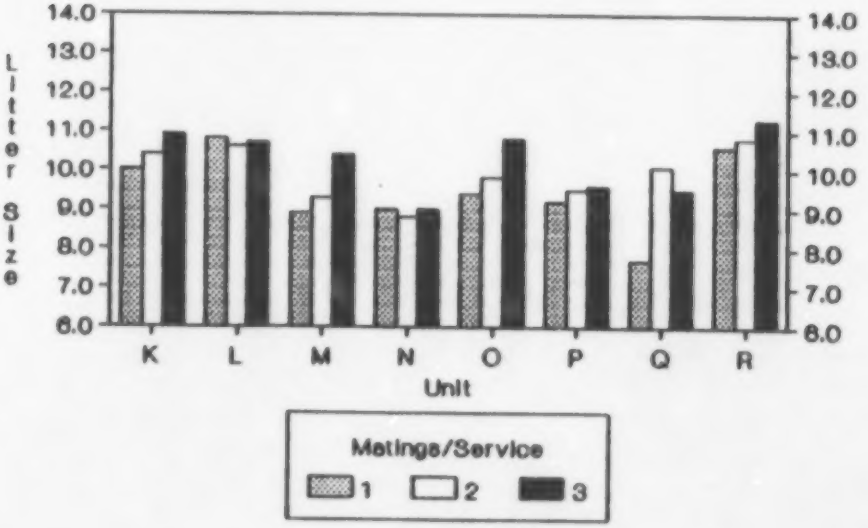


Figure II.3.5 (2b)
Matings/Service and Litter Size
• Large White Multiplication Units •



II.3.6

EFFECT OF TEST PERFORMANCE AND PRE-FARROWING BACKFAT LEVELS ON LITTER TRAITS

INTRODUCTION

The first objective of this study was to examine the association between pre-farrowing backfat levels on litter size and weight. The second objective was to determine the relationship, if any, between test performance and first litter productivity.

EXPERIMENTAL DESIGN

Between September 1988 and January 1990, first and second parity sows were weighed and backfat probed at L, C and K sites. Measurements were recorded when sows were being transferred from gestation stalls to farrowing crates. Litter traits analysed included total born, number born live, litter birth weight, number weaned and litter weaning weight. Separate analyses were carried out for each breed and parity. The data were adjusted to a constant sow weight, and litter traits were regressed on sow backfat values. Sire of sow was also included in the model as a fixed effect.

To evaluate the relationship between test performance and first litter performance, records on 454 Landrace and 513 Large White gilts, farrowing between spring of 1987 and winter of 1989, were collected. Traits included total born, number, born live and litter birth weight. The data were adjusted for the effects of sire of gilt and year-season of farrowing. Average daily gain (kg/d) on test, and backfat (mm) at loin (L) and rib (C and K) sites (see Appendix A, pg 126) were included as regression covariables in the model.

RESULTS

Means and standard deviations of litter traits and pre-farrowing sow weight are presented for both Landrace and Large White sows in Table II.3.6 (1). Regressions of litter traits on backfat are presented in Table II.3.6 (2). Although regressions were not significantly different from 0.0, fatter sows tended to farrow smaller litters but weaned more pigs/litter. Logically, we would expect sows farrowing larger litters to have less backfat; energy would be diverted to the extra piglets. "Fatter" second parity Large White sows were able to wean larger numbers of heavier pigs than their thinner contemporaries.

Regressions of first parity litter traits on test performance are presented

in Table II.3.6 (3). Average daily gain on test was not significantly correlated with litter size or weight, but there was a tendency for faster growing gilts to produce more pigs/litter. In Large Whites, each .10 kg/d increase in gain corresponded to an increase of .39 pigs born; in Landrace, an increase of .10 kg/d in gain corresponded to an increase of .13 pigs born. Breed differences in the regression of litter traits on backfat were evident. Landrace gilts with higher loin backfats tended to farrow larger litters, while the reverse trend was seen in Large Whites. Similarly, higher K fat measurements was associated with smaller litters in Landrace but large litters in Large Whites. Although these "trends" are interesting, perhaps the most important point to remember was that test performance was not significantly associated with prolificacy.

SUMMARY

Pre-farrowing backfat levels were lower in sows farrowing larger litters, suggesting energy and nutrients were being diverted from fat layers to feed the extra piglets. There was little evidence to suggest test performance was correlated with first litter performance.

Table 11.3.6 (1)
Means and standard deviations of litter traits and pre-farrowing sow weight

	Landrace		Large White	
	Parity 1	Parity 2	Parity 1	Parity 2
Number of litters	138	44	152	47
Total born	10.56 +/- 2.40	10.55 +/- 3.18	9.37 +/- 2.93	9.55 +/- 2.56
Born live	9.94 +/- 2.31	10.02 +/- 3.02	8.67 +/- 2.89	9.02 +/- 2.63
Litter birth weight (kg)	13.90 +/- 3.40	13.55 +/- 3.84	12.16 +/- 3.98	13.04 +/- 3.12
Number weaned	8.33 +/- 2.38	6.18 +/- 4.02	7.68 +/- 2.66	7.62 +/- 3.12
Litter wean weight (kg)	52.89 +/- 15.63	39.25 +/- 26.86	47.84 +/- 17.18	48.66 +/- 20.17
Pre-farrowing sow weight (kg)	195.6 +/- 15.70	219.6 +/- 15.33	194.4 +/- 16.57	223.9 +/- 16.75

Table 11.3.6 (2)
Regression of litter traits on backfat

		Landrace		Large White	
	Backfat(mm)	Parity 1	Parity 2	Parity 1	Parity 2
Number born	L	-.1391	-.2942	-.0205	-.0724
	C	-.0750	-.4164	-.1303	-.2879
	K	-.0734	-.2829	-.1350	-.3040
Number born live	L	-.1110	-.2761	-.0414	-.2103
	C	-.0400	-.4079	-.0532	-.3297
	K	-.0597	-.2708	-.0548	-.4139*
Litter birthweight[a] (kg)	L	-.0069	-.0523	-.0595	.0135
	C	-.0038	-.0417	.0286	-.1681
	K	-.0326	-.0254	-.0138	.1511
Number weaned	L	.0943	.0904	-.0067	.0590
	C	.0712	-.0647	.0315	.0070
	K	.1337	-.0170	-.0360	.0371
Litter weaning weight[b]	L	-.0867	-.1766	-.2733	1.1607**
	C	-.0021	-.0789	-.3847	1.0715**
	K	-.0054	-.1011	-.1183	.6236

* P = 0.05; ** P = .01
[a] adjusted for number born live
[b] adjusted for number weaned

Table II.3.6 (3)
Regression of first parity litter traits on test performance

	Landrace			Large White		
	Total born	Born live	Litter weight (kg)	Total born	Born live	Litter weight (kg)
Intercept	8.3753	8.2904	11.0288	9.4919	7.6327	10.9148
Average daily gain (kg/d)	3.8589	2.4688	3.1286	1.2937	.9156	-.3479
Backfat (mm):						
L	.0067	.0659	.2891	-.1891*	-.2039*	-.1890
C	.0203	-.0823	-.0765	-.0247	.0167	.0785
K	-.1695	-.1157	-.3030	.0693	.1168	.0729

* P = .05

II.3.7

TRENDS IN LITTER SIZE OF MULTIPLICATION HERDS

INTRODUCTION

The purpose of this study was to observe trends in litter size of Landrace and Large White Multiplication units and to quantify changes per unit time.

EXPERIMENTAL DESIGN

EASICARE's 'Litter Analysis' program, in conjunction with the 'Consolidation' program, was used to derive average monthly litter sizes of Landrace and Large White Multiplication units for the contract period of April 1987 through to February 1990.

RESULTS

Trends in average monthly litter size are illustrated in Figures II.3.7 (1a) and (1b) for Landrace and Large White Multiplication units, respectively. Regression of litter size on month-year in Landrace units revealed annual improvements in the ordet of .29 pigs/litter/year (litter size = 10.5 + .02(month)). Between April of 1987 and July of 1988, average litter size in Large White's was extremely variable from month to month, and decreasing over time. Since July of 1988 however, slight improvements have been noted in the order of .10 pigs/litter/year (litter size = 9.69 + .0084(month)).

SUMMARY

Over the term of the contract, small increases in litter size of .29 pigs/litter/year in Landrace units and, since July 1988, .10 pigs/litter/year in Large White units were observed. At present, N.P.D. selection does not include prolificacy, it was therefore reassuring to observe that litter size has not been compromised.

REFERENCES

Easicare Computers Ltd. 1981. Easicare Pig Data Systems (Program). Upton House, Beeford, Driffield, East Yorkshire, YO25, 8AF, England.

Figure II.3.7 (1a)
Trends in Litter Size
• Landrace Multiplication Units •

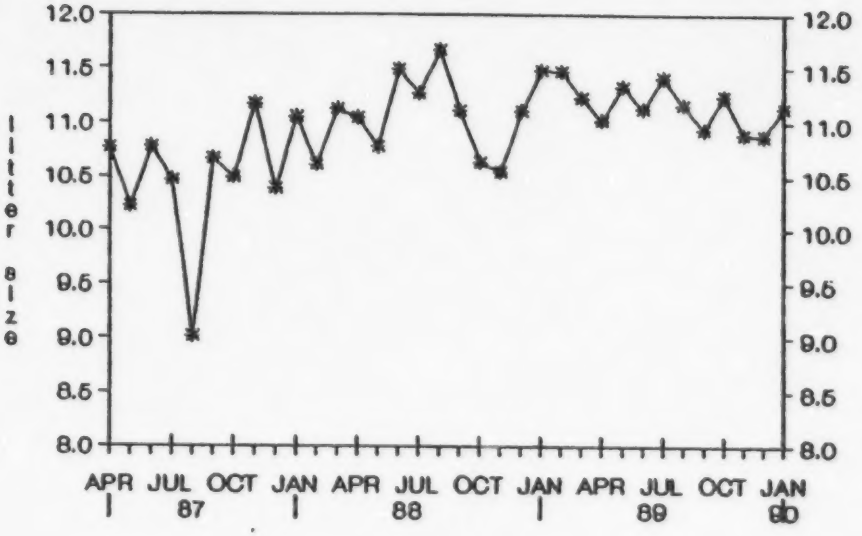
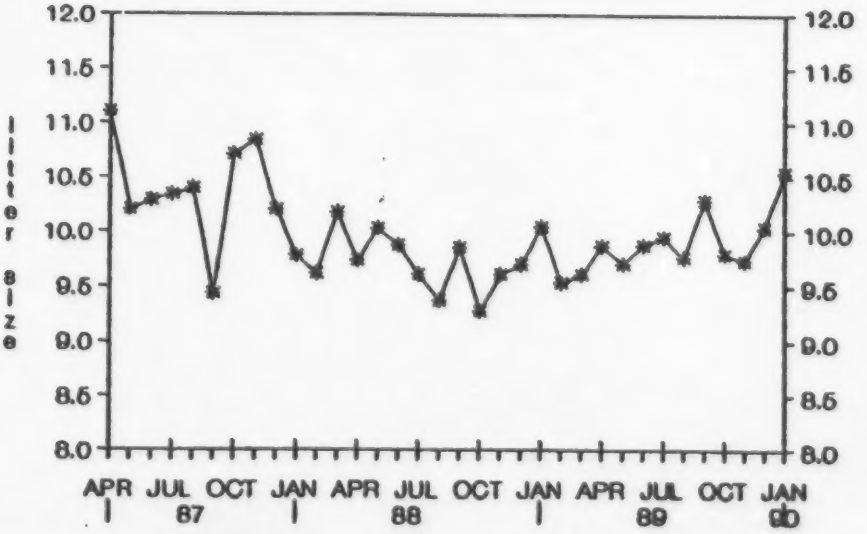


Figure II.3.7 (1b)
Trends in Litter Size
• Large White Multiplication Units •



III.1
CONTRACT

OBJECTIVE

Research and develop a superior breeding animal forced to the limit of its growth performance capabilities without compromise to structural soundness and longevity.

BACKGROUND AND RATIONALE

Growth Performance and Structural Soundness

It is an industry commonplace that the modern, high-performing breeding animal is structurally less able to withstand variable or sub-optimal management conditions. No work has been done to demonstrate any relationship between structural soundness and growth performance or to produce prediction models for soundness using growth performance.

ACTION PLAN

a) Current Base Line

Landrace:	daily gain (ADG)	0.94
	feed conversion (FC)	2.29
Large White:	daily gain (ADG)	0.92
	feed conversion (FC)	2.24

Goals		Apr 88	Apr 89	Feb 90
LR	ADG	0.94	0.95	0.96
	FC	2.29	2.27	2.25
LW	ADG	0.92	0.93	0.94
	FC	2.24	2.22	2.20
Improvement		0.00%	1.00%	1.00%

b) Type of trials would be individual feed conversion test trials on males over a fixed time period. Program is as follows:

* Fixed time test 49 days
* Fixed on-test weight 40 kg (+/- 2 kg)
* Pigs tested in groups of 5 with individual feeding twice per day
* Feed measured twice per day
* Fixed feed allowance of (per pig) :

900 grams/feed	week 1
1000 grams/feed	week 2
1100 grams/feed	week 3
1200 grams/feed	week 4
1300 grams/feed	week 5
1400 grams/feed	week 6
1500 grams/feed	week 7

- End of test period pigs identified, weighed, probed and feed consumption calculated.
- Numbers tested to be 40 boars/week

III.2
REALIZATION OF ACTION PLAN

a) Actual and contract test performance values for Landrace and Large White feed tested males

LANDRACE	ADG (kg/d)			Feed Conversion		
	Contract	Actual	Contract - Actual	Contract	Actual	Contract - Actual
Apr 87 - Mar 88	0.94	0.93	+0.01	2.29	2.37	-0.08
Apr 88 - Mar 89	0.95	0.93	+0.02	2.27	2.36	-0.09
Apr 89 - Feb 90	0.96	0.95	+0.01	2.25	2.33	-0.08
Improvement	+0.02	+0.02		-0.04	-0.04	

LARGE WHITE	ADG (kg/d)			Feed Conversion		
	Contract	Actual	Contract - Actual	Contract	Actual	Contract - Actual
Apr 87 - Mar 88	0.92	0.91	+0.01	2.24	2.35	-0.11
Apr 88 - Mar 89	0.93	0.90	+0.03	2.22	2.36	-0.14
Apr 89 - Feb 90	0.94	0.94	+0.00	2.20	2.27	-0.07
Improvement	+0.02	+0.03		-0.04	-0.08	

The discrepancy between original contract values and actual values was, as in the first objective, related to changes which took place between August of 1986 when the contract was first drawn up and it's initiation in April of 1987. In addition to the problems which typically accompany herd expansion, rations were no longer purchased but home-milled; this may have had an effect on the consistency of performance.

Relative to actual values in the first year of the contract, the objectives of the contract were met.

III.3
RESEARCH PROJECTS

III.3.1 GENERAL INTRODUCTION

Since the variation, and more specifically genetic variation, associated with traits sometimes differ in populations selected with varying intensities and success, variance components were estimated for test performance traits in both N.P.D. Landrace and Large White feed tested boars. Trait heritabilities and genetic and phenotypic correlations between traits were calculated using these variance component estimates (III.3.2.).

Part b of the Action Plan (III.2) specified that a number of relevant trials would be carried out using information from individually feed tested males. Accordingly, growth and feed intake curves on individually feed tested pigs were derived and reported in section III.3.3. To ensure pigs were "forced to the limit of (their) growth performance capabilities without compromise to structural soundness, two separate trials designed to either (1) increase growth by feeding a "challenge diet" or (2) decrease growth rate by feeding a "typical grower dieT" were carried out to determine whether feet and leg traits were significantly affected (III.3.4). Further to this, regression analyses of selected feet and leg traits on test performance were carried to determine the effect of growth rate and backfat on structural soundness (III.3.5). As well, a survival analysis to determine whether females with better test performance were more likely to be culled for feet and legs was carried out (III.3.6).

Having demonstrated the association between test performance and structural soundness, it then becomes necessary to demonstrate that improvements in test performance have, in fact been made. Trends in growth rate, feed conversion and backfat were plotted for the term of the contract (III.3.7).

III.3.2
GENETIC AND PHENOTYPIC PARAMETERS OF TEST PERFORMANCE TRAITS

INTRODUCTION

The success of a particular breeding program depends largely on the heritability of trait(s) under selection. Heritability is defined as the proportion of phenotypic (observed) variation due to additive gene effects and can be expressed mathematically as follows:

$$h^2 = V_{genetic} / V_{phenotypic}$$
$$= V_{genetic} / (V_{genetic} + V_{environmental})$$

For a given trait, differences in variation, both genetic and environmental, are often observed between different populations of pigs (i.e. breeds or line within a breed). Accordingly, differences in heritability estimates might also be expected. As well, increases in heritability can be achieved through a reduction in environmental variance, such as the standardization of test environment. For these reasons, estimates of genetic and environmental variances for certain traits in a specific population of pigs are often of interest.

The objective of this study was to estimate genetic and environmental variances for N.P.D. test performance traits. And, using these estimates, calculate trait heritabilities as well as genetic and phenotypic correlations between traits.

EXPERIMENTAL DESIGN

Test performance records, collected between January 1987 and November 1989, were available on 1820 landrace and 2832 Large White individually feed tested boars. Boars were placed on test at approximately 40 kg liveweight for a period of 8 weeks. Start and end-of-test weights, average daily gain (ADG, kg/d) and feed conversion (FC) on test and end-of-test backfat probes at loin (L) and rib (C and K) sites were recorded for each boar. Distribution of records across sires and dams is presented in Table III.3.2 (1).

Separate analyses were carried out for each breed according to the following model:

$$y_{ijklm} = u + b_1 X_{1ijklm} + ys_i + source_j + sire_{ik} + dam_l + error_{ijklm}$$

where

y_{ijklm}	is an observation on the $ijklm^{th}$ pig,
u	is the population mean,
b_1X_{1ijklm}	is the regression of y_{ijklm} on start weight (ADG, FC) or end weight (L, C, K),
ys_i	is the fixed effect of year-season of start of test, i=1,9,
$source_j$	is the fixed effect of the j^{th} source of sire, j=NPD, AI
$sire_k$	is the random effect of the k^{th} sire nested within the i^{th} source, $N(0,V_s)$,
dam_l	is the random effect of the l^{th} dam, $N(0,V_d)$, and
$error_{ijklm}$	is the random error associated with an observation on the ijklmth pig, $N(0,V_e)$.

Year-season's were based on start of test day and were defined as 1 of 3 four month periods (1:Jan-Apr, 2:May-Aug and 3:Sep-Dec) in each of 3 years (1987, 1988 and 1989), for a total of 9. Since many dams had several litters sired by different boars throughout the 3 year period, dams were considered cross-classified with sires. Variance components were estimated using a single-trait REML program (Meyer, 1987). Both sire and dam variance components were assumed to contain one-quarter of the additive genetic variation. Dam variance components also contain dominance, maternal and other common environmental effects. Genetic and phenotypic covariances between two traits were obtained by first summing the two traits, estimating variance components of the sum and then solving the equation:

$$Covariance_{1.2} = (Variance_{1+2} - Variance_1 - Variance_2) / 2$$

Heritabilities were computed as $(4.0 * V_s) / (V_s + V_d + V_e)$, correlations between two traits were calculated as $(COV_{1.2}) / (V_1 + V_2)^{**.5}$.

RESULTS

Overall means and standard deviations of test performance traits for each breed are presented in Table III.3.2. (2). No significant breed effects were noted for any of the traits; although, Landrace boars had slightly better ADG's but poorer FC's than Large White boars.

Heritability Estimates

Estimates of sire and error variances and heritability are given for each trait and breed in Table III.3.2 (3). Heritability estimates for ADG and FC were comparable to literature estimates (Hutchens and Hintz, 1981). Respective values for Landrace and Large White were .27 and .36 for ADG and .35 and .47 for FC. Although heritability estimates for backfat in Landrace were comparable to

literature estimates, those for Large Whites were considerably higher at .84, .64 and .69 for L, C and K probe fats, respectively. Literature estimates of heritability for backfat rarely exceed .60 (Hutchens and Hintz, 1981).

Comparatively high estimates of additive genetic variance and hence heritabilities were noted for most traits, particularly in Large Whites. A number of explanations are worthwhile considering. The discrepancy may, to an extent, be due to errors in estimation. Alternatively, since all testing was conducted in the same facility and under the same management, we would expect environmental variation to be minimized, which may have resulted in the increased heritability estimates. In most instances, heritability estimates are based on performance records from a number of different herds. The increased genetic variation may also be attributed to the introduction of external stock via artificial insemination. Since October of 1987, a total of 16 Large White and 12 Landrace A.I. boars were sampled. And, although genetic origin of the boars varied considerably, none were related to N.P.D. stock which was originally derived from the U.K.

Correlations

Genetic and phenotypic correlations between test performance traits are reported in Table III.3.2. (4). Correlations between ADG and FC were large and negative for both Landrace (r_g = -0.87, r_p = -0.83) and Large White's (r_g = -0.79, r_p = -0.83). These high correlations likely reflect the type of feed test used. Boars were fed to scale, twice per day for a period of 40 minutes. And, although the feeding scale was quite liberal, the imposition of feeding times constitutes a form of restriction in itself. Under these circumstances and compared to ad libitum feed testing, correlations between growth rate and feed efficiency would be expected to be higher.

Hutchens and Hintz (1981) reported an average correlation between ADG and backfat of 0.0, based on 15 different scientific publications. Similar estimates were noted in Large Whites but not in Landrace. Genetic correlations between ADG and L, C and K backfats were +0.63, +0.85 and +0.58, respectively. Phenotypic correlations were +0.42, +0.41 and +0.38, respectively. If Landrace boars were being heavily restricted in terms of feed consumption, they may never have had the opportunity to achieve their genetic potential for growth rate or fat deposition. Indeed, examination of patterns in feed consumption and refusals, as well as results from a trial offering 1.5 times the normal allotment of feed throughout test, confirmed that Landrace boars were being heavily restricted on test. The same was not true for Large Whites. The large and positive phenotypic correlation between growth rate and backfat in Landrace boars was likely "forced" by limiting

feed offered. Since it is not N.P.D.'s intention to limit consumption or appetite, a new feeding scale offering increased feed amounts was initiated in March of 1990. Feed restriction would not, however, explain why the genetic correlations were also large and positive. There are couple of reasons why this may have occurred; (1) insufficient data coupled with large standard errors of estimation or (2) confounding in data set (i.e. no distinction between a year-season and dam, etc..).

As anticipated, the positive correlations between FC and L, C and K fats indicate that inefficient pigs tend to be fatter. In both breeds, genetic correlations were higher than phenotypic correlations.

The extremely high, positive genetic correlations between between L, C and K fats confirm these traits are, in fact, simply 3 different measures of the same gene effect. Gu et al., (1989) reported similar findings in a much larger study involving 167 Landrace sires and 164 Large White sires.

All estimates have standard errors of prediction associated with them. Standard errors provide some idea as to the range of values which might have been estimated. For instance, an estimate of 1.01 and standard error of 0.05 would imply the estimate 1.01 could just have easily been 0.96 (1.01 - 0.05) or 1.06 (1.01 + 0.05), or any value in between. Smaller standard errors and hence more accurate estimates can be achieved by increasing the number of observations. Theoretically, correlations range between -1.0 and +1.0. Several of the genetic correlations between backfats were greater than +1.0. And, although standard errors were not computed in this study, the discrepancies were likely a function of standard errors in prediction. Most estimates were reasonable and within theoretical limits.

SUMMARY

Small environmental variances, due to a standard test environment, together with large additive genetic variation, resulted in fairly high heritability estimates for most traits. Heritability estimates for Landrace and Large Whites, respectively, were .27 and .36 for ADG, .35 and .47 for FC, .55 and .84 for L fat, .35 and .64 for C fat and .37 and .69 for K fat. Increased genetic variability was attributed mostly to the inclusion on non-related genetic material (A.I. boars) over the term of the project. As a consequence, increased opportunities to exploit genetic potential and further accelerate the rate of genetic progress were gained.

Favourable correlations between ADG and FC, and FC and backfat were observed

for both breeds. Genetic correlations of close to +1.0 between L, C and K backfat values suggest they are simply three different measures of the same gene effect. Correlations of near 0.0 between ADG and backfat were noted for Large White boars, whereas highly positive and unfavourable correlations between ADG and backfat were estimated for Landrace boars. Positive phenotypic correlations may have been the result of insufficient feed allotments and steps have since been taken in hopes of rectifying the situation. The high genetic correlations between ADG and backfat in Landrace were suspect and likely due to insufficient data and/or confounding of effects in the data.

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Meyer, K. 1987. Restricted maximum likelihood (REML) programs for the analysis of animal breeding data. Institute of Animal Genetics, Edinburgh University, Scotland.

Table III.3.2 (1)

Distribution of records across sires and dams

	Landrace	Large White
Number		
Records	1820	2832
Sires	55	66
Dams	420	549

Table III.3.2 (2)

Means of test performance traits

	Landrace		Large White	
	Mean	s.d.	Mean	s.d.
Start weight (kg)	39.44	2.841	39.00	2.897
End weight (kg)	84.61	5.090	83.19	5.576
ADG (kg/d)	.93	.089	.91	.093
FC	2.36	.203	2.34	.200
Backfat (mm) :				
L	13.27	2.074	13.53	2.290
C	9.75	1.507	9.89	1.624
K	11.27	1.586	11.19	1.942

Table III.3.2 (3)

Estimates of variance components and heritabilities for performance traits

	Landrace			Large White		
	V_{sire}	V_{error}	h^2	V_{sire}	V_{error}	h^2
ADG (kg/d)	.00050915	.00596046	.2682	.00073966	.00671120	.3581
FC	.00336181	.03070422	.3489	.00464600	.03099527	.4716
Backfat (mm)						
L	.51596485	2.68848290	.5458	1.02280546	3.17928804	.8432
C	.17180227	1.51653896	.3515	.38879461	1.77652649	.6398
K	.30524994	2.45024415	.3739	.61937252	2.67235131	.6914

Table III.3.2 (4)

Genetic and phenotypic correlations between test performance traits[1]

	ADG	FC	L	C	K
Landrace					
ADG (kg/d)		-0.87	+0.63	+0.85	+0.58
FC	-0.83		+0.21	+0.27	+0.18
Backfat (mm)					
L	+0.42	+0.14		+0.97	+0.94
C	+0.41	+0.12	+0.66		+1.01
K	+0.38	+0.13	+0.73	+0.67	
Large White					
ADG (kg/d)		-0.79	-0.03	-0.08	-0.09
FC	-0.81		+0.36	+0.40	+0.44
Backfat (mm)					
L	-0.00	+0.18		+1.02	+0.97
C	-0.02	+0.15	+0.68		+1.04
K	-0.02	+0.18	+0.73	+0.73	

[1] genetic correlations (r_g) on upper diagonal; phenotypic correlations (r_p) on lower diagonal

III.3.3

PATTERNS OF GROWTH AND FEED INTAKE IN THE TEST PERIOD

INTRODUCTION

In the past 20 years, selection in pigs has focused on the improvement of lean tissue deposition and yield. Overall, this had a dramatic effect on growth rates and nutritional requirements of pigs; albeit different selection schemes have met with varying success. For this reason, the nature of growth curves in specific populations, selected with varying intensity and success, is of interest particularly when formulating rations.

The objective of this study was to derive growth and feed intake curves for N.P.D. Landrace and Large White performance tested boars.

EXPERIMENTAL DESIGN

Between October 3rd, 1988 and March 3rd, 1989, weekly weights and individual feed intakes were recorded on 38 Landrace and 76 Large White performance tested boars. Boars were housed in pens of 5 equipped with individual feeding stalls. Following a one week acclimatization period, they were placed on test at approximately 40 kg for 7 weeks. Feed was offered twice daily for a period of 45 minutes per feeding. Excess feed was weighed back and recorded. Boars were removed from test on the afternoon of the 49th day. Consequently, the last afternoon feeding was omitted and feed intake for the last week represents consumption for 6.5 days rather than 7 days. Data were analysed using SAS's (1985) GLM procedure according to the following model:

$$y_{ijk} = u + b_1 x_{1ijk} + breed_i + batch_j + e_{ijk}$$

where

y_{ijk}	is an observation on the ijk^{th} pig,
u	is the population mean,
$b_1 x_{1ijk}$	is the regression of weekly weight/feed intake on start of test weight,
$breed_i$	is the fixed effect of the i^{th} breed,
$batch_j$	is the fixed effect of the j^{th} batch (= week/year on test),
$error_{ijk}$	is the random error associated with the ijk^{th} observation, $N(0,V_e)$.

Least squares means of weekly weights and feed intakes were generated and used to plot growth and feed intake curves.

RESULTS

Mean weights, plotted against week on test, and accompanying regression equations are illustrated in Figure III.3.3 (1). Landrace boars gained approximately 6.7 kg per week while Large White boars gained 6.4 kg per week. Significant breed differences were observed from the 4th through last week of test.

Figure III.3.3 (2) depicts weekly feed intake patterns for both breeds. Regression equations were computed using information from the first 6 weeks of test since, as mentioned previously, feed consumption for the last week was based on intake for only 6.5 days.

Large White boars consistently consumed less feed per week compared to Landrace boars. This difference was statistically significant through to the 4th week of test.

SUMMARY

Growth curves and feed intake curves were derived for Landrace and Large White performance tested boars. Results are best summarized in the following linear regression equations:

Weight on test (kg)	Feed intake on test (kg)
LR : y = 31.8 + 6.7 (week of test)	LR : y = 10.8 + 1.27 (week of test)
LW : y = 32.0 + 6.4 (week of test)	LW : y = 10.3 + 1.23 (week of test)

REFERENCES

Statistical Analysis System. 1985. SAS/STAT guide. SAS inst. Inc., Cary, N.C.

Figure III.3.3. (1)
Growth Patterns in Tested Pigs

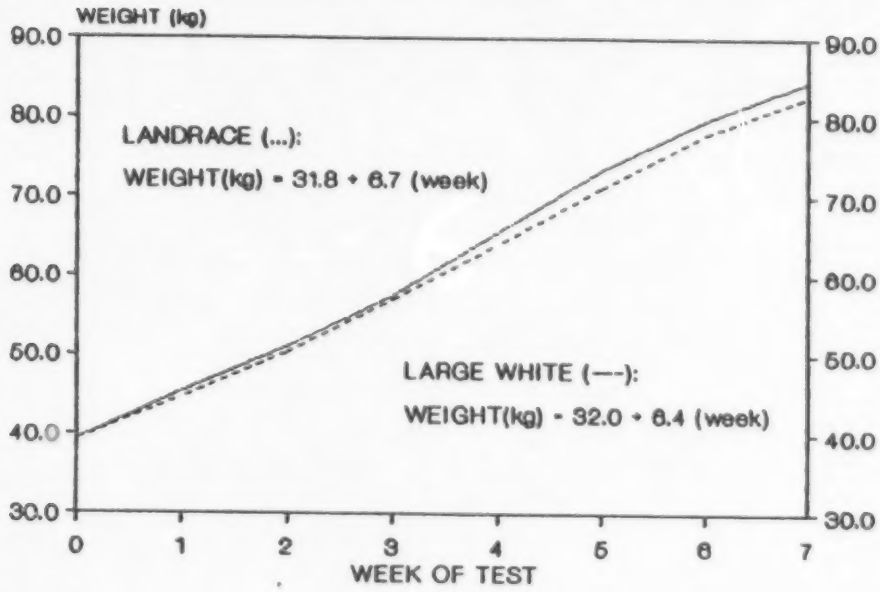
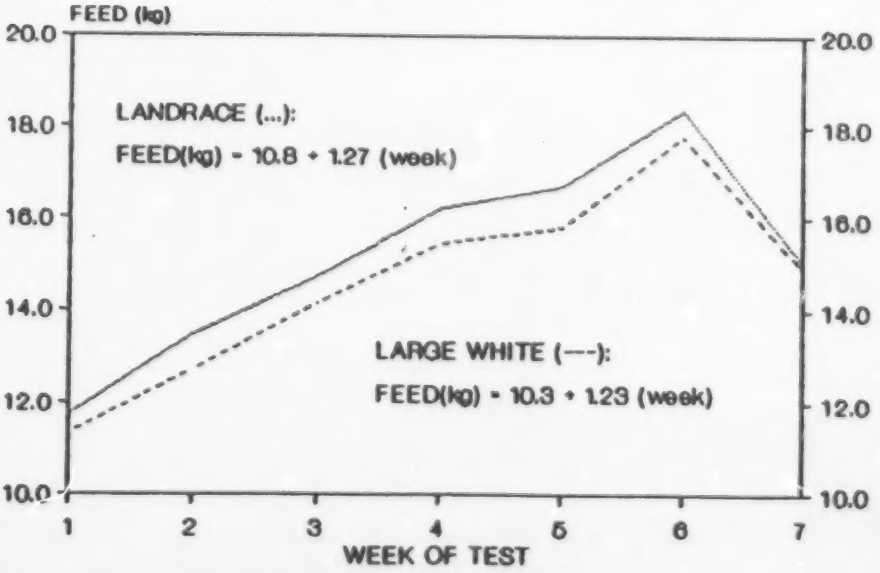


Figure III.3.3 (2)
Feed Intake Patterns in Tested Pigs



* WEEK 7 CONSUMPTION BASED ON 6.5 DAYS

III.3.4
EFFECT OF DIET ON FEET AND LEG TRAITS

INTRODUCTION

It has often been suggested there exists a negative correlation between growth rate and structural soundness of feet and legs. Two separate experiments designed to either increase (trial 1 - "challenge diet") or decrease (trial 2 - "typical grower diet") the growth rate of pigs, relative to a control, were conducted to determine whether scores for structural soundness were significantly affected.

EXPERIMENTAL DESIGN

A summary of the data available for analysis in trials 1 and 2 is provided in Table III.3.4. (1). Boars were placed on test at approximately 40 kg, for a fixed time period of 49 days and fed twice daily. Pigs were assigned randomly to pens in groups of 5. Attempts to represent both breeds, Large White and Landrace, in the ratio of 3:2 in each pen were made. Half of the pens received the test ration, while the remaining pens received the control ration. Composition of the diets is given in Table III.3.4 (2). In the first trial, pigs fed the "challenge" ration received slightly higher levels of crude protein and approximately 2.7% more energy relative to the control group. Alternately, pigs fed the "typical grower" ration in trial 2 received, on average, 4.76% less crude protein and approximately 2.8% less energy when compared to the control group. Each feeding period was approximately 40 minutes in duration, while the amount of feed offered per feeding was as follows:

	First 7 feedings	Next 7 feedings
Week 1	850 g	900 g
Week 2	950 g	1000 g
Week 3	1050 g	1100 g
Week 4	1150 g	1200 g
Week 5	1250 g	1300 g
Week 6	1350 g	1400 g
Week 7	1450 g	1500 g

To determine individual feed consumptions, the amount of feed refused by each pig was recorded and, at the end of test, subtracted from the total amount of feed

offered during the testing period. At the end of test, pigs were weighed and backfat probed at loin (L) and rib (C and K) sites. Performance traits included average daily gain (ADG, kg/d), feed conversion (FC) and average daily feed intake (FI, kg/d) on test and average C and K backfat (mm) measurements. As well, a standardized performance index (mean = 0.0, standard deviation = 1.0), based on ADG, FC and average C and K backfat was computed for each pig.

Pigs were scored for structural soundness of feet and legs at the end of performance test. A total of 13 front and back leg traits were considered. Traits included gait, and in the front legs: knock knees, over at knee, turning out, down at pasterns, up on toes and uneveness of toes, and in the back legs: closeness of hocks, sickle hocks, turning out, down at pasterns, up on toes and uneveness of toes. Scores were assigned as either 0 (normal), 1 (slight abnormality) or 2 (severe abnormality).

The SAS General Linear Models (GLM, 1985) procedure was used to analyse the data. The following model was used for analysis in both trials:

$$y_{ijkl} = u + b_1X_{1ijkl} + breed_i + diet_j + sire_{ik} + dam_{ikl} + error_{ijkl}$$

where

y_{ijkl}	is an observation on the $ijkl^{th}$ boar,
u	is the population mean,
b_1X_{1ijkl}	is the regression of test performance/structural soundness score on start of test weight (kg),
$breed_i$	is the fixed effect of the i^{th} breed, i = LR, LW,
$diet_j$	is the fixed effect of the j^{th} diet, j = test, control,
$sire_{ik}$	is the random effect of the k^{th} sire, nested within the i^{th} breed, $N(0,V_s)$,
dam_{jkl}	is the random effect of the l^{th} dam, nested within the k^{th} sire and i^{th} breed, $N(0,V_d)$, and
$error_{ijkl}$	is the random error associated with the $ijkl^{th}$ observation, $N(0,V_e)$.

RESULTS

Means and standrad deviations of test performance and structural soundness traits for all boars in each trial are provided in Table III.3.4 (3). Estimates of the differences between diets are presented in Table III.3.4 (4) for both test performance and structural soundness traits. In both trials, the test ration achieved the desired result. In the first trial, pigs fed the "challenge" ration had significantly higher daily gains, feed intakes and backfat levels, relative to the control group. In the second trial, pigs fed the "typical grower" ration gained less, ate more feed and had significantly poorer feed conversions when compared to control pigs. The pigs had less backfat, but overall had poorer

indexes.

In trial 1, boars fed the "challenge" ration had lower scores for 'down at pasterns' (-.326) in the back legs accompanied by higher scores for 'up on toes' (.319) in the back legs. Although differences were not significant, the same trend was observed in the second trial; faster growing pigs on the 'control' diet were more likely to be 'up on their back toes'. In the second trial, pigs fed the "typical grower" ration were more likely to be knock kneed in the front legs (.230) and less likely to have their back legs turning out (-.197).

SUMMARY

In view of the negative association between pigs considered to be 'up on toes' and lifetime survival, results from this trial would suggest faster growing pigs are predisposed to earlier breakdown due to feet an leg problems. If the relationship between growth rate and structural soundness is causal, these findings have some serious implications. However, prior to making any "sweeping statements", it was decided to further investigate the phenomena with a larger data set. Research results are presented in section III.3.5.

REFERENCES

Statistical Analysis System. 1985. SAS/SATA Guide - GLM procedure. SAS Inst. Inc., Cary, N.C., U.S.A.

Table III.3.4 (1)

Data summary

	Trial 1	Trial 2
Number	148	154
Landrace	74	80
Large White	74	74
Number of Sires	31	29
Number of Dams	79	83

III.3.4 (2)

Composition of diets

	Trial 1[a]		Trial 2[b]	
	Control	Challenge	Control	Typical Grower
Moisture (%)	11.2	10.3	11.5	12.6
Crude protein (%)	19.0	19.7	21.9	17.2
Calcium (%)	.82	1.20	1.51	.74
Phosphorus (%)	.74	.88	1.29	.71
Estimated Energy (%TDN)	74.0	76.0	73.0	70.5
Estimated Digestible Energy (kcal/kg)	3263	3351	3219	3130

[a] Averages over 5 feed analyses taken at regular intervals throughout trial

[b] Averages over 2 feed analyses taken during trial

Table III.3.4 (3)

Means and standard deviations of test performance and structural soundness traits

	Trial 1			Trial 2		
	Mean	+/-	s.d.	Mean	+/-	s.d.
Test Performance						
Average daily gain (kg/d)	.93		.06	.91		.08
Feed conversion	2.29		.12	2.37		.14
Average daily feed intake (kg/d)	2.13		.10	2.14		.13
Average C and K backfat (mm)	10.67		1.30	11.02		1.22
Index score	-.05		.76	.01		.76
Structural Soundness						
Gait	1.134		.441	1.162		.459
Front legs:						
knock knees	.772		.411	.935		.349
over at knee	.966		.527	.961		.446
turning out	1.020		.387	1.026		.204
down at pasterns	.698		.580	.812		.632
up on toes	.221		.443	.136		.373
uneveness of toes	.644		.489	.734		.477
Back legs:						
closeness of hocks	.383		.479	.351		.442
sickle hocks	.772		.436	1.019		.404
turning out	.772		.435	.935		.318
down at pasterns	.537		.573	.734		.589
up on toes	.423		.578	.175		.359
uneveness of toes	.946		.444	.929		.278

Table III.3.4 (4)

Estimates of diet differences for test performance and structural soundness traits

	Trial 1 Challenge - Control	Trial 2 Typical Grower - Control
Test Performance		
Average daily gain (kg/d)	.045*	-.033
Feed conversion	-.051	.149**
Average daily feed intake (kg/d)	.051*	.068
Average C and K backfat (mm)	.755*	-.595
Index score	.187	-.330
Structural Soundness		
Gait	.023	.117
Front legs:		
knock knees	.028	.230*
over at knee	-.042	.018
turning out	.149	.000
down at pasterns	.062	-.002
up on toes	-.093	-.059
uneveness of toes	-.003	-.201
Back legs:		
closeness of hocks	-.099	-.217
sickle hocks	-.131	-.222
turning out	-.057	-.197*
down at pasterns	-.326*	.202
up on toes	.319*	-.088
uneveness of toes	.014	.010

* $P < .05$

** $P < .01$

III.3.5

RELATIONSHIP BETWEEN TEST PERFORMANCE AND SELECTED FEET AND LEG TRAITS

INTRODUCTION

Assimilation of information gathered from various analyses on structural soundness data suggests that, of all the traits studied, two in particular offer the greatest potential for altering feet and leg structure with a view to reducing the incidence of premature breakdown due to feet and leg problems. These two traits are 'down at pasterns' and 'up on toes'.

In section III.3.4, pigs fed a "challenge" ration exhibited less desirable back leg structure (lower 'down at pastern' scores and higher 'up on toes'). These pigs also had increased daily gains and backfat levels. The inference was clear: faster growing pigs had poorer feet and leg structure. The first objective of this study was to re-evaluate this "assessment" using a much larger data set. Observations based on a large number of records are more accurate and consequently, more reliable.

A second objective was to estimate the genetic and phenotypic correlations between 'down at pasterns' and 'up on toes', in both the front and back legs, to determine if these traits were simply measures of the same condition, as hypothesized in section I.3.5.

EXPERIMENTAL DESIGN

Records from 5268 Landrace and 5749 Large White performance tested pigs were used for the analysis. All pigs had been scored for feet and leg structure at the end of test. Details of the data set were given in section I.3.3. Performance information included growth rate on test (ADG, kg/d) and average loin (L) and rib (C) fat measurements. Traits included 'down at pasterns' and 'up on toes', in both the front and back legs. The model and programs used for analysis were similar to those described in section I.3.3., with a few exceptions. The covariate weight at scoring was excluded when feet and leg scores were regressed on ADG, but retained when regressing traits on average backfat.

Covariances between 'down at pasterns' and 'up on toes' were estimated by first summing the two traits, estimating variance components, and solving the following equation : $COV_{1.2} = (COV_{1+2} - V_1 - V_2) / 2.0$. Correlations were computed as $r = COV_{1.2}/(V_1 * V_2)^{**.5}$.

RESULTS

Regressions of traits on ADG and average backfat are presented for both breeds in Table III.3.5. In all instances, faster growing pigs with less backfat had more desirable feet and leg structure, namely higher 'down at pastern' scores and lower 'up on toes' scores. The absence of an antagonistic relationship between test performance and structural soundness has also been observed by Rothschild, et al. (1988).

Results from the "challenge" trial (III.3.4) were not in agreement with those reported herd. Certainly, the results from this trial involving over 10,000 pigs are more credible than those of III.3.4 involving only 150 pigs. Nevertheless, the discrepancy is disturbing; why did faster growing pigs on the "challenge" ration have significantly less desirable scores for 'down at pasterns' and 'up on toes' in the back legs ? the answer probably lies in asking more questions and carrying out further experiments. The "challenge" experiment results may not be reproducible, or possibly the solution lies in the composition or relative proportion of nutrients in the diet.

Genetic and phenotypic correlations between 'down at pasterns' and 'up on toes', in both the front and back legs, are presented in Table III.3.5 (2) for both breeds. Correlations were quite high; genetic correlations neared 80% while phenotypic correlations were closer to 50%. In section I.3.5, it was postulated that scores of 0 for 'up on toes' were likely to preclude scores of 0 for 'down at pasterns' in the same pig. Correlations between these two traits tend to confirm this and suggest they are simply two different measures of the same trait.

SUMMARY

Results indicate that desirable leg structure, characterized by moderate (1) 'down at pastern' and normal (0) 'up on toes' scores, is not compromised by increased growth rate or reduced backfat levels. In fact, regressions of these traits on 'down at pastern' and 'up on toes' would suggest the reverse is true. Genetic correlations between 'down at pasterns' and 'up on toes' were high (80%), suggesting they were measures of the same trait.

REFERENCES

Rothschild, M.F., Christian, L.L. and Jung, Y.C. 1988. Genetic control of front-leg weakness in Duroc swine. II. Correlated responses in growth rate, backfat and reproduction from five generations of divergent selection. Lives. Prod. Sci. 19:473-485.

Table III.3.5 (1)

Regression of selected feet and leg traits on growth rate and backfat[1]

	Landrace				Large White			
	ADG		Backfat		ADG		Backfat	
	slope	s.e.	slope	s.e.	slope	s.e.	slope	s.e.
Front legs:								
down at pasterns	.0052	.0085	.0225	.0085	.0059	.0077	.0151	.0077
up on toes	-.0125	.0047	-.0147	.0047	-.0024	.0051	-.0134	.0051
Back legs:								
down at pasterns	.0162	.0071	.0120	.0071	.0112	.0068	.0211	.0068
up at toes	-.0102	.0053	-.0071	.0053	-.0019	.0058	-.0142	.0058

[1] Average of loin (L) and rib (C) measurements

Table III.3.5 (2)

Genetic and phenotypic correlations between 'down at pasterns' and 'up on toes'

	Landrace	Large White
Front legs:		
genetic	-.72	-.79
phenotypic	-.47	-.51
Back legs:		
genetic	-.75	-.87
phenotypic	-.49	-.56

III.3.6

RELATIONSHIP BETWEEN TEST PERFORMANCE AND FINAL DISPOSAL

INTRODUCTION

The purpose of this study was to determine if test performance could be used to predict which sows were more likely to be culled for feet and leg problems.

EXPERIMENTAL DESIGN

Records on 1469 Landrace and 862 Large White performance tested sows from 19 different Multiplication units were analysed using SAS's LIFETEST procedure (1988). Status of sows was classified as either (1) censored or (2) failed. Censored observations were defined as those animals which were either still in the herd at the end of the contract February 1, 1990 and had yet to fail or animals which were removed from the system for reasons other than feet and leg problems. Failed observations were defined as those animals which were culled for feet and leg problems. Survival was defined as age (days) to censor or fail. On-test average daily gain (ADG, kg/d) and end-of-test probe backfat (mm) at loin (L) and rib sites (C and K) were included in the model as covariates. Separate log-rank and Wilcoxon chi-square values were computed to test each covariates' association with failure time. Further detail on survival analyses was provided in section I.3.6.

RESULTS

Means and standard deviations of test performance traits are presented in Table III.3.6 (1) for both breeds. Within breed chi-square values for both log-rank and Wilcoxon tests are given for each covariate in Table III.3.6 (2). Lifetime survival was not significantly affected by ADG on test in either breed. Backfat probe values at the end of test were not associated with survival in Landrace sows, yet there was a significant association between L and C fats with lifetime in Large White sows. Those with lower L and C fats were more likely to be culled for feet and leg problems.

SUMMARY

There was no evidence to support the hypothesis that faster growing pigs were more likely to fail due to feet and leg problems. Interestingly enough, it was found that Large White sows with higher end-of-test backfat levels were less likely to fail due to feet and leg problems.

Table III.3.6 (1)

Means and standard deviations of test performance traits

	Landrace	Large White
Number of sows	1469	862
Number censored	1342	781
Number failed	127	81
Average daily gain (kg/d)	.75 +/- .08	.79 +/- .08
Backfat (mm)		
L	14.17 +/- 2.54	16.45 +/- 3.06
C	10.82 +/- 11.97	11.80 +/- 2.13
K	11.71 +/- 2.47	13.56 +/- 2.68

Table III.3.6 (2)

Association of failure time with test performance : chi-square values

	Landrace		Large White	
	Log Rank[1]	Wilcoxon	Log Rank	Wilcoxon
Average daily gain (kg/d)	.6310 .4270	.5765 .4477	.0230 .8795	.0313 .8593
Backfat (mm)				
L	1.7280 .1887	1.8056 .1798	4.9552 .0260	5.3338 .0209
C	.0005 .9817	.0013 .9711	5.1151 .0237	5.5235 .0188
K	.5438 .4609	.5894 .4426	1.9374 .1639	2.0660 .1506

[1] chi-square values for both log rank and Wilcoxon tests are superscripted with probability associated with the hypothesis H_o : test statistic (log rank/Wilcoxon) = 0. If the probability were .05, then there was only a 5% chance that the test statistic was equal to 0.0, or a 95% chance that the test statistic was not equal to 0.0.

III.3.7

TRENDS IN GROWTH RATE, FEED CONVERSION AND BACKFAT

INTRODUCTION

The objective of this exercise was to quantify the rate of improvement in test performance traits demonstrated over the term of the project.

EXPERIMENTAL DESIGN

Test performance records on 1804 Landrace and 2622 Large White boars, evaluated between April 1987 and February 1990, were included in the analysis. Traits included average daily gain (kg/d) and feed conversion on test and average backfat (mm) at the end of test. Backfat was defined as the average of loin (L) and rib (C) measurements. Within-breed monthly averages were computed for each trait and SAS's REG procedure (1985) was used to estimate separate regression equations. The slope of the line would provide a quantitative estimate of the rate of phenotypic improvement which had taken place over the course of the contract.

RESULTS

Literature estimates of heritabilities (h^2) for all three test performance traits near .40. Phenotypic standard deviations ($V_p^{**.5}$) for average daily gain, feed conversion and backfat are approximately .09 kg/d, .20 and 2 mm, respectively. Assuming a standard intensity of selection (i) of 1.4 and generation interval (gen) of 17 months, the annual response to individual selection for each of these trait can be estimated as follows:

Annual Response to Selection $= (i\ h^2\ (V_p)^{**.5}) / gen * 12$ months

Average daily gain (kg/d) $= (1.4 * .40 * .09)^{**.5} / 17 * 12 = .036$
Feed conversion $= (1.4 * .40 * .20)^{**.5} / 17 * 12 = .079$
Backfat (mm) $= (1.4 * .40 * 2)^{**.5} / 17 * 12 = .79$

Since all three traits are combined into a selection index constructed to yield simultaneous improvements in all three traits, the expected improvement in individual traits is somewhat less than if single trait selection were practised. If all traits were weighted equally, the effectiveness of the index in improving one of the traits would be inversely related to the square root of the number of traits in the index (Falconer, 1989). Therefore, we would expect each of the

three traits to improve at a rate of 58% (1/ ($3^{**.5}$)) relative to the rate for single trait selection. In other words, we would expect annual improvements of .021 kg/d (.036 * 58%) in average daily gain, 0.046 (.079 * 58%) in feed conversion and .46 mm (.79 * 58%) in backfat, respectively. Although the N.P.D. index does not place equal weight on all three traits and the exact rates of progress are further complicated by correlations between traits, the values calculated in this exercise do provide guidelines to gauge rates of improvement.

Trends in average daily gain, feed conversion and backfat are presented in Figures III.3.7 (1, 2 and 3), respectively. The slope of the line refers to monthly changes in each trait. There were some problems with the feed in early 1989 which affected test performance; fortunately, these were rectified in time to meet the contract objective. For Landrace and Large Whites, annual improvements were in the order of .015 kg/d and .021 kg/d for growth rate, .025 and .029 for feed conversion and 0.35 mm and 0.36 mm for backfat. Although consistent with theoretical expectations in terms of direction and magnitude, realized improvements were somewhat less than anticipated, as is often the case.

SUMMARY

As stated, the objective of this exercise was to demonstrate improvements in test performance traits over time and to quantify these improvements. Rates of improvement were, by and large, consistent with theoretical expectations.

REFERENCES

Falconer, D.S. 1989. Introduction to quantitative genetics.

Figure III.3.7 (1)
Trends in Average Daily Gain (kg/d)

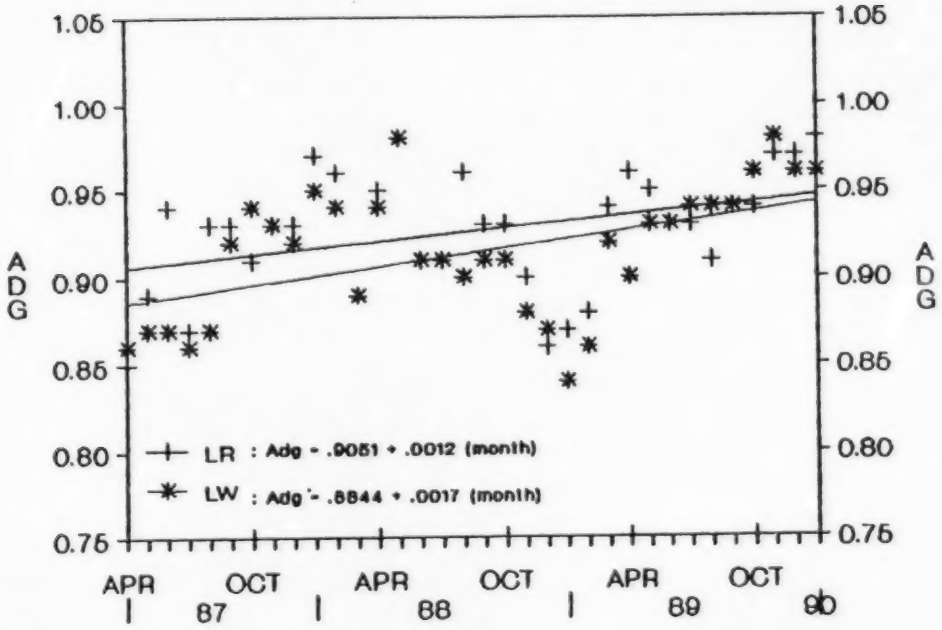


Figure III.3.7 (2)
Trends in Feed Conversion

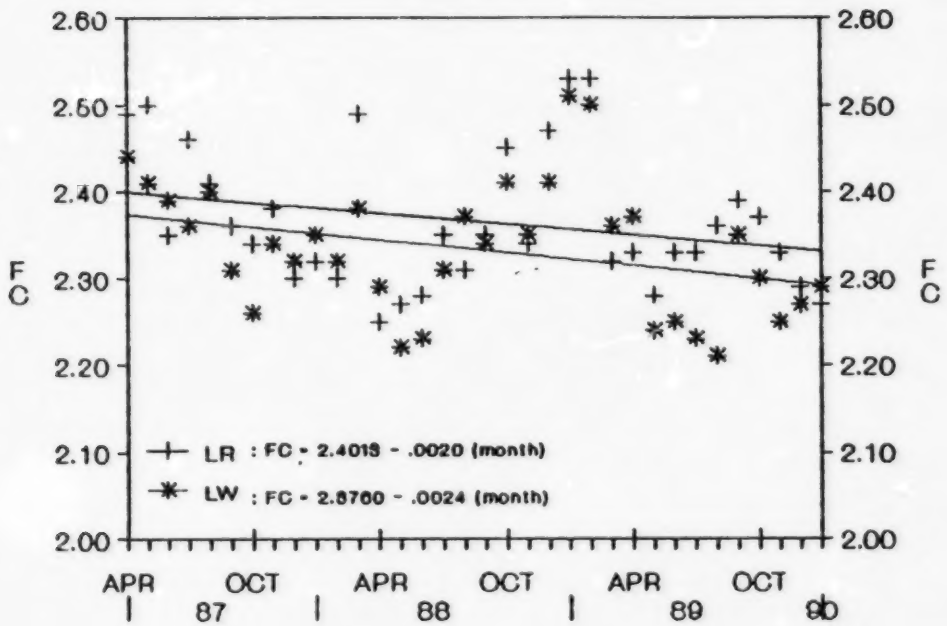
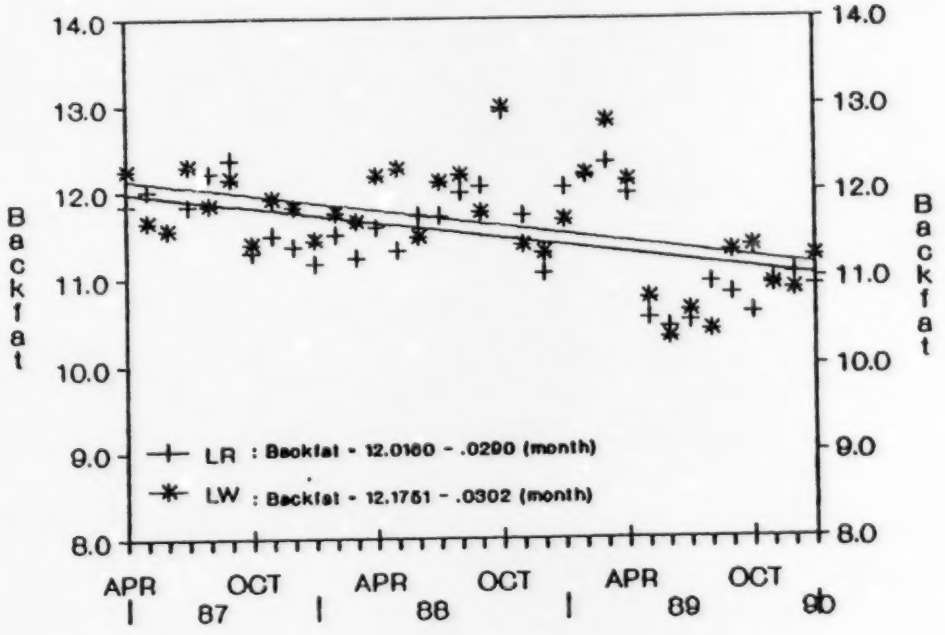


Figure III.3.7 (3)
Trends in Average Backfat (mm)



IV.1
A.I. PROGRAM

INTRODUCTION

In August of 1987, N.P.D. (Canada) initiated a program to sample external genetics via artificial insemination (A.I.). Up to 10% of Nucleus matings were designated for the project. Number and source of boars sampled was outlined in section II.3.3.

The objective of this exercise was to compare test performance and litter traits of A.I. and N.P.D. sired progeny.

EXPERIMENTAL DESIGN

Between July 18th, 1988 and February 1, 1990, Landrace (LR) and Large White (LW) test performance information on 1187 A.I. and 9415 N.P.D. sired progeny was recorded. Pigs were tested either in pen groups of 12 (-FC) or in groups of 5 in pens equipped with individual feeding stalls (+FC). Only males were individually feed tested; feed was offered twice daily, for approximately 40 minutes each time. Pigs were placed on test at approximately 40 kg for a period of 8 weeks. At the end of test, pigs were weighed and probed at loin (L) and rib (C and K) sites. In the case of individually feed tested males, feed consumption through the test period was also recorded. Traits measured included average daily gain (ADG, kg/d), backfat (mm) and, in the case of feed tested males, feed efficiency (FC). A standardized index score (mean = 0.0, std = 1.0), computed within sex (F vs M) and type of test (+FC vs -FC), was also included for analysis.

Traits were analysed separately for each breed, sex and type of performance test using SAS's GLM procedure (1985) and according to the following model:

$$y_{ijkl} = u + moyr_i + source_j + sire_{jk} + error_{ijkl}$$

where

y_{ijkl}	is an observation on the $ijkl^{th}$ pig,
u	is the population mean,
$moyr_i$	is the fixed effect of the i^{th} month-year of start of test, i = 1, 19,
$source_j$	is the fixed effect of the j^{th} source of sire, j = A.I., N.P.D.,
$sire_{jk}$	is the fixed effect of the k^{th} sire nested within the j^{th} source,

$error_{ijkl}$	is the random error associated with an observation on the $ijkl^{th}$ pig, $N(0,V_e)$.

Limitations in computer memory precluded the addition of a dam of pig term in the model.

By February 1990, a number of A.I. daughters had farrowed either one or two litters of their own. Total pigs born, pigs born live and average pig birthweight (adjusted for born live) of these sows were compared to N.P.D. daughters, also in their first or second parities which farrowed during the same time period. Data were analysed separately for each breed using the following model:

$$y_{ijklm} = u + parity_i + moyr_j + source_k + sire_{kl} + error_{ijklm} \quad (+b_1X_{1ijklm})$$

where

y_{ijklm}	is an observation on the $ijklm^{th}$ daughter,
u	is the population mean,
$parity_i$	is the fixed effect of the i^{th} parity, i = 1,2,
$moyr_j$	is the fixed effect of the j^{th} month-year of farrowing, j = 1,10,
$source_k$	is the fixed effect of the k^{th} source of sire, k = A.I., N.P.D.,
$sire_{kl}$	is the fixed effect of the l^{th} sire, nested within the k^{th} source,
$error_{ijkl}$	is the random error associated with an observation on the $ijklm^{th}$ daughter, $N(0,V_e)$.
(B_1X_{1ijklm})	is the regression of number of pigs born live on average piglet birthweight (not included in analysis total born and born live).

As in the first analysis, limitations in computer memory precluded the addition of a dam of sow term in the model.

RESULTS

Mean test performance of A.I. and N.P.D. sired progeny is presented in Table IV.I (1). No significant differences in ADG were noted between A.I. and N.P.D. sired pigs. However, N.P.D. individually feed tested males were significantly more feed efficient than their A.I. sired contemporaries. Similarly, A.I. sired pigs were consistently fatter at L, C and K probe sites. With few exceptions, these differences were statistically significant. In most cases, average N.P.D. index, which includes ADG, backfat and FC (individually feed tested males) was higher in N.P.D. sired pigs, but this difference was only significant in Landrace feed tested males. Slightly better growth rates of A.I. sired group test pigs tended to offset differences in backfat and accounted for the absence of

significant differences in N.P.D. performance test indexes.

Table IV.1 (2) summarizes the average merit of A.I. and N.P.D. sired progeny selected for Nucleus, Multiplication and Sale/Fill. The final disposition of a pig is determined by it's standardized index score. Minimum scores sought for Nucleus and Multiplication are 1.7 and 1.0 for males, respectively, and 1.0 and 0.0 for females, respectively. Average indexes were in keeping with these criteria and N.P.D.'s goal of continually selecting for improved breeding stock.

Calculation of the percentage of animals selected from each source was useful in determining whether a disproportionate number of A.I. or N.P.D. sired animals were dispatched to different tiers in the breeding pyramid. This was not the case, suggesting inclusion of both A.I. and N.P.D. sired progeny into the herd was warranted.

Litter parameters of A.I. and N.P.D. daughters are presented for both breeds in Table IV.1 (3). Litters of A.I. daughters were larger and weighed more at birth than N.P.D. sows. The differences were significant at the 10% level ($P < .10$) for total born in both Landrace and Large White sows as well as litter birth weight for N.P.D. sows.

SUMMARY

Sampling of A.I. boars has proven a worthwhile venture. The benefits of increased genetic variation and reduced inbreeding levels have been reviewed in several other sections of this report. In general, A.I. progeny tended to be fatter and have poorer feed conversions, yet many competed successfully alongside N.P.D. contemporaries and warranted inclusion in breeding herd. Preliminary assessment of litter traits revealed a distinct advantage in A.I. daughters. The advantage was likely attributable to heterosis arising from the crossing of two distinct lines (U.K. vs Canada) and may prove a particularly successful method of improving litter size in the short term.

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Table IV.1 (1)

Comparison of test performance of A.I. and N.P.D. sired progeny

		Landrace			Large White		
	Source	M (+FC)	M (-FC)	F (-FC)	M (+FC)	M (-FC)	F (-FC)
Number tested	A.I.	170	120	383	162	105	247
	N.P.D.	839	852	2726	1283	1106	2609
ADG (kg/d)	A.I.	.91	.85	.79	.92	.88	.82
	N.P.D.	.93	.84	.78	.93	.86	.80
	Prob.[1]						
FC	A.I.	2.44			2.37		
	N.P.D.	2.34			2.31		
	Prob.	**			*		
Backfat (mm)							
L	A.I.	13.95	14.22	14.80	13.92	15.58	16.86
	N.P.D.	12.76	13.40	13.98	13.29	14.45	15.75
	Prob.	**	*	**	*	*	**
C	A.I.	10.05	10.37	10.99	9.86	11.48	11.96
	N.P.D.	9.23	9.94	10.39	9.64	10.56	11.13
	Prob.	**		**		**	**
K	A.I.	11.64	12.24	12.62	11.62	12.96	14.07
	N.P.D.	10.85	11.72	11.93	10.82	11.82	12.90
	Prob.	*		**	**	**	***
N.P.D. Index	A.I.	-.42	-.05	-.07	-.17	.05	-.04
	N.P.D.	.10	.03	.08	.08	.03	.06
	Prob.	**					

[1] Probability that differences between A.I. and N.P.D. values were significant

ns = not significant; * P < .05 ; ** P < .01; *** P < .001.

Table IV.1 (2)

Average merit of A.I. and N.P.d. sired progeny selected for Nucleus, Multiplication and Sale/Fill

	Landrace						Large White					
	M (+FC)		M (-FC)		F (-FC)		M (+FC)		M (-FC)		F (-FC)	
	A.I.	N.P.D.	A.I.	N.P.D.	A.I.	N.P.D.	A.I.	N.P.D.	A.I.	N.P.D.	A.I.	N.P.D.
Number tested	170	839	120	852	383	2726	162	1283	105	1106	247	2609
Nucleus												
no. selected	2	16	4	18	42	278	3	21	1	20	24	293
% selected	1.18	1.91	3.33	2.11	11.0	10.20	1.85	1.64	0.95	1.81	9.72	11.23
N.P.D. index	1.60	1.83	1.93	1.93	1.25	1.20	1.61	1.76	2.12	1.90	1.04	1.23
Multiplication												
no. selected	5	38	3	27	72	469	11	61	2	74	43	505
% selected	2.94	4.53	2.50	3.17	18.80	17.20	6.79	4.75	1.90	6.69	17.41	19.36
N.P.D. index	1.04	1.17	1.06	1.16	.37	.38	1.13	1.20	1.17	1.13	.40	.31

Table IV.1 (3)

Least squares means of litter traits of A.I. and N.P.D. daughters

	Landrace			Large White		
	A.I.	N.P.D.	Prob.[a]	A.I.	N.P.D.	Prob.
Number of litters	66	258		30	250	
Number of sires	5	29		4	29	
Total born	11.16	10.07	.0590	10.94	9.49	.0937
Born live	9.96	9.56	.4620	9.87	8.81	.2133
Litter birth weight[b] (kg)	1.42	1.37	.1484	1.52	1.42	.0898

[a] Prob. is probability level of testing hypothesis H_o : A.I. = N.P.D.. For instance, if P = .0590, then we are 94.1% (1.00 - .0590) confident that the difference observed between A.I. and N.P.D. daughters was a true differences.

[b] adjusted for number of pigs born live.

IV.2

HALOTHANE REACTIVITY IN A LANDRACE NUCLEUS POPULATION

INTRODUCTION

Pigs affected with porcine stress syndrome (PSS) may die suddenly when stressed, develop malignant hyperthermia (rapid elevation of body temperature) when exposed to halothane gas and give rise to pale, soft and exudative (PSE) pork at slaughter (Taylor, 1986).

Although PSE meat can develop in halothane negative pigs (Barton-Gade, 1984) there is a strong relationship between PSE and the halothane gene. Murray et al. (1989) reported an incidence of 87% PSE pork in halothane positive pigs compared to an incidence of 0-4% in halothane negative pigs. PSE carcasses typically exhibit greater drip loss and poorer curing yields (Murray, 1986). Recent evidence also suggests that pigs carrying the halothane gene may have smaller litters (Sather and Murray, 1989).

Increased awareness of the various disadvantages associated with PSS and PSE have generated industry concern regarding the halothane gene and it's prevalence in the Canadian pig population. Efforts to reduce the incidence and minimize it's effects will likely be rewarded in the near future.

The objective of this study was to identify and eliminate the use and sale of halothane positive Landrace boars throughout the N.P.D. breeding pyramid.

EXPERIMENTAL DESIGN

Halothane testing was first introduced in the N.P.D. Nucleus on March 30th, 1988. For the first 2 months, all Landrace male and female pigs were tested; since then, only males have been tested. Pigs, between 6 and 8 weeks of age, were exposed to a 4 minute, 5.0% halothane challenge. Reactor pigs were, and continue to be, excluded from performance testing and possible selection.

RESULTS

Between March 30th, 1988 and October 26th, 1989, a total of 3684 Landrace pigs were halothane tested. Of those, 3441 (93.4%) were non-reactors and 243 (6.6%) were halothane sensitive. Since the population is undergoing selection, standard formulas for estimating the percentage of carrier and non-carriers were not used. They are very sensitive to non-random mating situations and unless the

population is in Hardy-Weinberg equilibrium their results can be very misleading.

In 1989, a cooperative trial between N.P.D. and the Lacombe Research Station in Alberta was carried out to investigate the carcass characteristics and meat quality of 40 Landrace and 40 Large White Nucleus pigs. PSE meat was described in 4 of the 40 Landrace carcasses; the remaining 90% were assigned normal colour and structure scores. This compares well with commercial estimates of 15% PSE in Canadian hogs reported by Murray (1986) using 1978 data.

SUMMARY

The incidence of reactors in this study was considerably higher than National levels estimated at 1.4% in Landrace using ROP station test data (Hubbard et al., 1989). Concern has been expressed that National estimates may not be representative of incidence levels in the entire population since reactor pigs, which are typically less thrifty than their heterozygous (carrier) littermates, are less likely to be submitted for station test (Dr. Austin Murray, personal communication).

Ample evidence exists to confirm the presence of halothane positive pigs throughout Canadian swine herds. It is only through continued research and cooperative efforts of seedstock producers that the problem will be controlled and perhaps eliminated.

Until methods for detection of carriers become commercially available, efforts to control the problem will be limited largely to the identification and culling of reactor pigs. N.P.D. has, and will continue to be part of this effort.

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IV.3
INBREEDING LEVELS

INTRODUCTION

Inbreeding refers to the degree of relationship between individuals in a population and is a function of population size (Falconer, 1989). The practice of mating closely related animals is sometimes used to increase the frequency of a particularly desirable trait or gene. Unfortunately, other less desirable characteristics also tend to appear in highly inbred individuals; namely a reduction in overall fitness. Toro et al. (1988) reported a decrease in the number of live pigs born of -.20 for every 10% increase in dam inbreeding.

The objective of this study was to calculate and monitor inbreeding levels in the N.P.D. Nucleus herd.

EXPERIMENTAL DESIGN

A data file containing pedigree information was created. All breeding animals entered into the herd since it's establishment in 1983 were included. Foundation stock were assumed unrelated. Inbreeding coefficients were derived from the inverse of the numerator relationship matrix (A^{-1}). Procedures were outlined in detail by Quaas (1976) and Henderson (1976).

RESULTS

Table IV.3 (1) lists mean inbreeding levels for each breed and sex. Only animals in the herd on December 27th, 1989 were included in the averages.

To help ensure minimal inbreeding levels, it has been N.P.D.'s policy to only mate together animals which were unrelated at grand-parent level. Accordingly, only 3 of 447 Landrace and 1 of 402 Large White sows were found to have inbreeding coefficients in excess of 10%. Mean inbreeding levels were well within acceptable limits ranging from 1.32 % for Large White males through 2.26% for Landrace females. These values compare well with Canadian breed averages (Kennedy, B.W., personal communication).

Approximately 20.4% of the animals in the herd had inbreeding coefficients of 0.00. This was possible through the regular introduction of external stock, via caesarian section and limited sampling of top A.I. station boars.

SUMMARY

Efforts to maintain minimal inbreeding levels in the Nucleus herd have proven successful. Average inbreeding levels are comparable to National averages and well below the value of 10% typically associated with decreased fitness and reproductive problems.

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Table IV.3 (1)

Inbreeding levels in the Nucleus herd

	Landrace		Large White	
	Females	Males	Females	Males
Number of animals	447	26	402	26
Inbreeding:				
Mean	.023	.015	.015	.013
Minimum	.000	.000	.000	.000
Maximum	.182	.066	.146	.049
Percentage of non-inbred animals	17.00	26.92	23.88	19.23

IV.4

PRODUCT DEVELOPMENT : TERMINAL SIRE LINE

INTRODUCTION

Historically, N.P.D. has offered purebred Large White and Landrace boars for sale to commercial producers. In recent years, considerable interest in the use of crossbred boars has been generated. Crossbred boars, particularly coloured boars, are often perceived as hardier and more aggressive breeding animals. A recent review by Buchanan (1988) summarized comparisons of purebred and crossbred boar performance. Significant advantages were noted for crossbreds in semen characteristics and breeding performance and success.

In April of 1988, N.P.D. initiated a program to introduce and develop a crossbred terminal sire. An outline of the program and it's current status are summarized in this report.

SUMMARY

INTRODUCTION OF STOCK

Several herds, identified as having superior breeding stock and meeting health guidelines outlined by the N.P.D. veterinarian, were contacted. A total of 12 Hampshire and 9 Duroc sows, from 5 different herds in Alberta, Manitoba and Ontario, were selected and caesarian-sectioned between August 13th, 1988 and November 11th, 1988. Piglets were transferred immediately to the Nucleus in Humboldt, Saskatchewan and fostered onto N.P.D. sows. Total born and average litter size for each breed is reported in Table IV.4 (1).

TEST PERFORMANCE

Of the total born, 77% of Hampshire and 80% of Duroc pigs completed performance test. Pigs were placed on test at approximately 40 kg for a period of 8 weeks. Average daily gain (ADG) on test, backfat at the end of test and, in the caseof males, feed conversion (FC) during test were recorded. A summary of test performance results is presented in Table IV.5 (2).

BREEDING HERD

To ensure original bloodlines were maintained in the first generation of matings, the top boar in each litter and, where possible, a "reserve boar" were

selected as herd sires. With the exception of one Duroc gilt, all females were entered into the breeding herd.

Breeding stock was scheduled for transfer to a separate barn in early April but there were several unforeseen delays. Consequently, first breeding for many of the gilts did not occur until 9 or 10 months of age. Problems inherent to late breeding were seen in the breeding and subsequent farrowing performance of the gilts.

Conception rates were 70.8% for Hampshires and 75% for Durocs. Total pigs born in October through December 1989 is given in Table IV.5 (3). Average litter size was significantly lower than that observed in the caesarian-sectioned sows.

CURRENT STATUS

A total of 16 Hampshire and 3 Duroc gilts remain to farrow in the first three months of 1990. Performance testing of litters has already begun. The best pigs will be selected to establish the Terminal Sire Line (TSL) Nucleus and Multiplication herds.

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Table IV.4 (1)

Litter Sizes of C-sectioned Sows

	Hampshire	Duroc
Litters:		
Number	12	9
Females born	63	45
Males born	58	43
Litter Size :		
Average	10.08	9.78
(+/- std. dev.)	2.02	3.67
Minimum	7	3
Maximum	13	13

Table IV.4 (2)

Average Test Performance of Hampshire and Duroc Pigs

	Hampshire		Duroc	
	Females	Males	Females	Males
Number	47	44	36	31
Average daily gain (kg/d)	.74 .07	.83 .09	.83 .09	.86 .08
Feed Conversion		2.59 .20		2.54 .20
Backfat (mm)[1]				
L	15.4 3.2	13.5 2.2	18.8 3.5	14.4 2.0
C	11.7 2.0	10.6 1.6	15.3 2.8	11.1 1.6
K	13.4 2.7	12.2 2.1	16.4 3.3	12.3 2.1

[1] L : Loin fat, 4 cm ahead of the hip bone and 5 cms from the centre line of the spine

C : Rib fat, over the outer curve of the last rib and 5 cms from the centre line of the spine

K : Rib fat, over the outer curve of the last rib and 8 cms from the centre line of the spine

Table IV.4 (3)

Litter Size of Hampshire and Duroc Gilts

	Hampshire	Duroc
Sows:		
Total	46	36
Farrowed Oct/89 - Dec/89	18	24
Due Jan/90 - Mar/90	16	3
Conception rate (%)	73.9	75.0
Litters (Oct/89 - Dec/89)		
Females born	61	74
Males born	61	72
Litter Size :		
Average	8.11	8.13
(+/- std. dev.)	2.81	2.10
Minimum	3	3
Maximum	15	11

IV.5

CARCASS COMPOSITION AND MEAT QUALITY IN NUCLEUS LANDRACE AND LARGE WHITE PIGS

INTRODUCTION

In June of 1989, a cooperative research trial between N.P.D. and the Lacombe Research Station, Lacombe, Alberta, was carried out.

The objectives of the trial were to compare carcass composition and meat quality of Landrace (LR) and Large White (LW) boars (M) and gilts (F) selected for efficiency of lean tissue growth.

EXPERIMENTAL DESIGN

A total of 80 cull Nucleus pigs was used in the study. The group consisted of equal numbers of performance tested LR and LW gilts and boars.

Pigs were placed on test at approximately 40 kg liveweight for a fixed time period; 7 weeks for boars and 8 weeks for gilts. Boars were housed in groups of 5 in pens equipped with individual feeding stalls. They were offered feed twice daily for a period of 45 minutes per feeding. Gilts were housed in groups of 12 and fed ad libitum. The test diet of 21% crude protein and 3300 kcal/kg DE was fed throughout the test period. At the end of test, pigs were weighed and backfat probed at L (loin, 5 cms from centre line of spine), C and K sites (outer curve of last rib, 5 and 8 cms from centre line of spine, respectively). Average daily gain (ADG kg/d) and, in the case of males, feed conversion (FC) on test were calculated for all pigs.

Pigs were transported from the Nucleus unit at Humboldt, Saskatchewan to Lacombe, Alberta and slaughtered within 24 hours of delivery. Standard slaughter and dissection techniques, described in detail by Martin et al. (1981), were used.

RESULTS

Data were analysed using SAS's (1985) General Linear Model procedures.

LIVE TEST PERFORMANCE

Mean test performance, by breed and sex is given in Table IV.5 (1). No significant breed effects were noted for growth rate on test or backfat at the end of test. However, Large White males had significantly better feed conversions than

their Landrace testmates. Boars had significantly higher growth rates and lower backfat levels than gilts.

CARCASS CHARACTERISTICS

Least squares means of carcass traits are reported in Table IV.5 (2). There were no significant breed or sex differences in plant weight (post-exsanguination). LW's had higher warm carcass weights and dressing percentages when compared to LR pigs. Similarly, gilts had higher warm carcass weights and dressing percentages when compared to boars. Carcass cooler shrinkage was similar for both breeds and sexes. LR pigs had carcasses which were 2 cm longer than LW pigs; no differences between sexes were observed.

Ruler fat measurements tended to be higher for LW pigs. Boars were significantly leaner than gilts.

No breed or sex differences were observed for probe fat. However, boars had significantly less lean depth measurements than gilts. This may have been due to the young age of the boars and their relative stage of maturity. Estimated lean yields for both breeds neared 52.0% with carcasses grading, on average, 109.1 index points using the Canadian Hog Carcass Grading/Settlement Grid.

Actual lean yield percentages, determined through carcass dissection, were between 1.0 % and 1.4% higher for LR and LW's, respectively, than estimated lean yields by electronic grading. Indexes based on actual lean yield percentages increased from 109.1 to 109.8 for LR and from 109.1 to 110.3 for LW's. Increases were due largely to improved lean yield percentage of boars.

COMMERCIAL AND LEAN YIELDS

Mean weights of commercial and lean products are given in Table IV.5 (3). Means were adjusted to a standard warm carcass weight and represent yields for a half carcass.

With the exception of heavier picnic weights in LW pigs, there were no breed differences in commercial yield of major wholesale cuts. Compared to LR, LW's had significantly higher lean yields in both the picnic and butt. Similar advantages were noted for boars. Differences in lean yield of loin and ham were not evident between breeds or sexes.

DISTRIBUTION OF TISSUES

The percentages of bone, fat and lean in each of the four major wholesale cuts are listed in Table IV.5 (4). Values were calculated as a percentage of total tissues (bone + fat + lean) and sum to 100% within each breed and sex.

MEAT QUALITY

i) Subjective measures

Frequency distributions of subjective colour and structure scores are depicted in Figures IV.5 (1) and (2), respectively. Scales for colour and structure range from 1 through 5, with a value of 3 denoting normal meat colour and structure. Of the 80 pigs used in this study, 75 had normal meat colour and structure scores; the remaining 4 LR and 1 LW were classified as having PSE (pale, soft and exudative) meat.

Marbling scores range from 1 (excessive marbling) through 9 (no marbling). Marbling scores of 7 are common in commercial situations. The frequency distribution of marbling scores is illustrated in Figure IV.5 (3) and suggest the majority of animals had very little, if any, visible marbling fat. Although marbling fat and eating quality are related, most recent studies conclude the correlations are low (Wood, 1987).

ii) Objective measures

Means of selected meat quality measures are presented in Table IV.5 (5). The rate of pH decline over a 24 hour period is often used to distinguish between PSE, normal and DFD(dark, firm, dry) meat. Values for both breeds were considered normal.

Luminosity, which is a measure of paleness can be used to detect DFD or PSE meat. Values can range from 0 though 100, with a typical average of 50. Readings in excess of 55 usually indicate PSE type meat.

Approximately 94% of the pigs (75 of 80) had luminosity readings within the normal range. The five pigs which had sub-optimal subjective colour and structure scores also had luminosity values greater than 55.

Expressible juice % is used to evaluate processing value of meat; values greater than 30% signify PSE meat. Although both breeds had acceptable values, the processing value of LW meat was better than LR.

Drip loss % and shear value are indicators of fresh meat quality. Values were within acceptable ranges, but LW meat, which had a lower drip loss %, was also more tender than LR meat.

No differences were observed between breeds in fat hardness, although boars had softer fat than gilts. Readings below 750 are indicative of soft fat, and readings below 700 characterize very soft fat which is more liable to split away from the lean. The relatively high percentage of pigs with fat scores below 750 is often associated with very lean pigs. Fat hardness is influenced by diet and the problem can be remedied by limiting quantities of unsaturated fats in the feed.

CORRELATIONS

Correlations between live performance and probe fat, lean yield and carcass index are reported in Table IV.5 (6). All correlations between live test performance and carcass value were favourable, ranging between 30% and 65%. The NPD index, which stresses improvement in lean tissue growth rate by combining growth rate, feed conversion and backfat was also strongly correlated with lean yield ($r = .66$), probe fat ($r = -.64$) and carcass index ($r = .52$).

SUMMARY

Compared to current commercial pig averages, NPD pigs used in this study offered a 5 to 6 index point advantage in carcass value with a corresponding advantage of 3 to 4% in carcass lean yield.

Based on both subjective and objective measures of meat quality, there was little evidence to support the claim that meat quality of very lean pigs is inferior. Meat quality was acceptable in both breeds, although LW's produced better fresh pork (colour, structure, drip loss and shear value) and appeared to have a higher processing value (lower expressible juice %) than LR pigs.

As part of NPD's commitment to quality, the company uses testing and selection procedures designed to improve lean tissue growth rate and lean tissue deposition. Evidence of this commitment was seen in the favourable correlations between carcass lean yield, probe fat and index with the NPD live performance index.

ACKNOWLEDGEMENTS

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Table IV.5 (1)

Least squares means of live test performance traits

	Breed		Sex	
	Landrace	Large White	Female	Male
Start weight (kg)	41.30	39.45 **	39.68	41.08 **
End weight (kg)	86.68	86.08	85.68	87.08
Age (d) at end of test	141.7	142.2	142.6	141.3
ADG (kg/d)	.87	.89	.82	.94 **
FC	2.32	2.18 *		
Backfat (mm):				
L	12.65	12.73	13.95	11.43 **
C	9.15	9.33	10.03	8.45 **
K	10.88	10.78	11.75	9.90 **

N.B. Breed and/or sex means postscripted by an asterisk(s) were significantly different

* $P < 0.05$

** $P < 0.01$

Table IV.5 (2)

Least squares means of carcass traits[1]

	Breed		Sex	
	Landrace	Large White	Female	Male
Plant weight (kg)	90.7	90.5	90.8	90.4
Warm carcass weight (kg)	76.5	77.0 *	77.9	75.5 **
Dressing %	82.8	83.3 *	84.4	81.7 **
Carcass cooler shrinkage (%)	2.56	2.53	2.55	2.55
Carcass length (cm)	82.3	80.3 **	81.3	81.2
Ruler measurements				
Maximum shoulder (mm)	32.2	34.1	35.5	30.8 **
10th rib (mm)	16.9	19.6 **	20.1	16.4 **
Maximum loin (mm)	25.7	26.3	28.5	23.6 **
Lumbar lean (mm)	13.5	14.5	16.1	12.0 **
Hennessy Grading Probe				
Fat (mm)	14.0	13.7	14.0	13.7
Lean depth (mm)	43.1	43.2	45.3	41.0 **
Lean yield (%)	51.8	51.9	51.9	51.8
Index	109.1	109.1	109.2	109.0
Carcass dissection				
Lean yield (%)	52.8	53.3	52.9	53.3
Index	109.8	110.3	109.2	110.8
Rib eye area (cm^2)	39.1	39.6	40.5	38.2 **

[1] Plant weight, warm carcass weight, dressing %, shrinkage and length adjusted to a constant liveweight
Ruler, probe and dissection measurements adjusted to a constant warm carcass weight

N.B. Breed and/or sex means postscripted by an asterisk(s) were significantly different

* $P < 0.05$

** $P < 0.01$

Table IV.5 (3)

Least squares means of commercial product and lean yields [1]

	Breed		Sex	
	Landrace	Large White	Female	Male
Commercial Product (kg)				
Picnic	3.54	3.71 **	3.56	3.68
Butt	3.43	3.34	3.23	3.54 **
Loin	7.43	7.29	7.42	7.31
Ham	8.22	8.21	8.28	8.15
Belly	3.62	3.55	3.64	3.53
Lean product (kg)				
Picnic	2.45	2.69 **	2.51	2.63 *
Butt	2.67	2.57 *	2.47	2.77 **
Loin	5.01	4.95	5.02	4.94
Ham	5.79	5.92	5.88	5.83

[1] Yields adjusted to a constant warm carcass weight

N.B. Breed and/or sex means postscripted by an asterisk(s) were significantly different

* $P < 0.05$

** $P < 0.01$

Table IV.5 (4)

Least squares means of % bone, fat and lean in carcass[1]

	Breed		Sex	
	Landrace	Large White	Female	Male
% Bone	11.32	11.10	10.95	11.46 **
Picnic	1.58	1.44 **	1.46	1.56 *
Butt	.75	.78	.72	.80 **
Loin	5.35	5.31	5.28	5.38
Ham	3.64	3.56	3.48	3.72 **
% Fat	24.52	23.71	24.86	23.36
Picnic	3.49	3.22 *	3.31	3.39
Butt	4.42	4.65	4.55	4.52
Loin	8.94	8.62	9.13	8.44
Ham	7.67	7.22	7.87	7.02 **
% Lean	64.16	65.20	64.19	65.17
Picnic	9.89	10.86 **	10.12	10.63 *
Butt	10.70	10.40	9.99	11.10 **
Loin	20.19	20.02	20.30	19.91
Ham	23.38	23.91	23.77	23.53

[1] Adjusted to a constant warm carcass weight

N.B. Breed and/or sex means postscripted by an asterisk(s) were significantly different

* $P < 0.05$

** $P < 0.01$

Table IV.5 (5)

Least squares means of objective measures of meat quality[1]

	Breed		Sex	
	Landrace	Large White	Female	Male
pH (45 min)	6.10	6.16	6.09	6.17
pH (final)	5.59	5.65 **	5.61	5.64
Luminosity (L^*)	52.48	50.89 *	52.20	51.17
Expressible juice (%)	28.79	25.89 **	27.97	26.71
Drip Loss (%)	2.57	2.24	2.44	2.37
Shear value (kg)	6.94	6.11 **	6.48	6.56
Fat hardness	761	759	782	738 **

N.B. Breed and/or sex means postscripted by an asterisk(s) were significantly different

* $P < 0.05$

** $P < 0.01$

Table IV.5 (6)

Correlations between live test performance and carcass traits[1]

	Fat (mm)	Lean Yield %	Index
ADG (kg/d)	-.31	+.36	+.31
FC	+.61	-.61	-.52
Backfat (mm):			
L	+.62	-.58	-.48
C	+.59	-.54	-.41
K	+.65	-.63	-.48
NPD index	-.64	+.66	+.52

[1] Fat (3rd-4th last rib), Lean yield % and Index based on Hennessy probe readings

Figure IV.5 (1)
DISTRIBUTION OF COLOUR SCORES

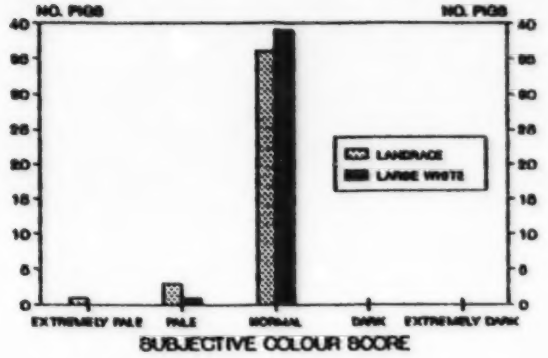


Figure IV.5 (2)
DISTRIBUTION OF STRUCTURE SCORES

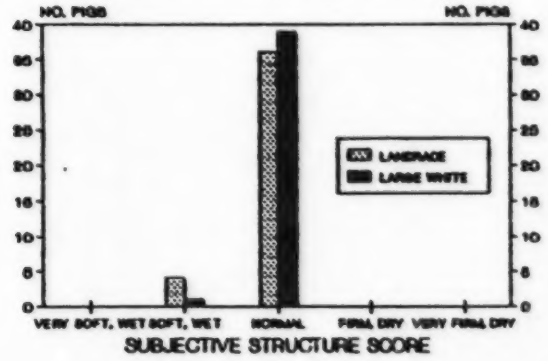
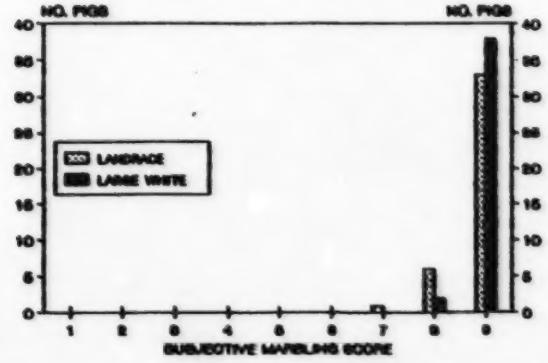
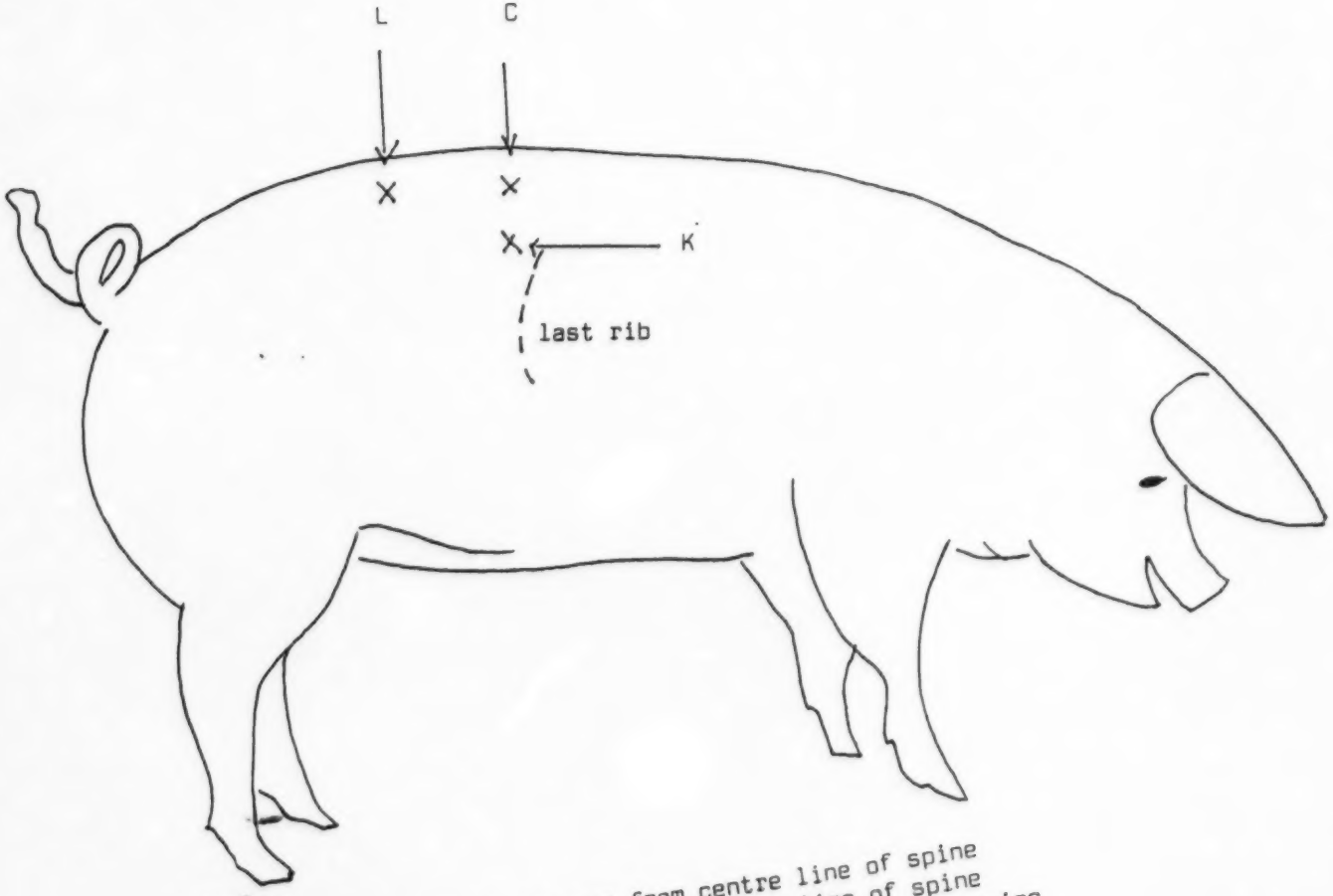


Figure IV.5 (3)
DISTRIBUTION OF MARBLING SCORES





C: outer curve of last rib and 5 cms from centre line of spine
K: outer curve of last rib and 8 cms from centre line of spine
L: 4 cms ahead of the hip bone and 5 cms from centre line of spine